Intentional Use of the Hawthorne Effect to Improve Oral Hygiene Compliance in Orthodontic Patients

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Abstract: The purpose of this study was to evaluate whether the home care of noncompliant adolescent orthodontic patients with "poor" oral hygiene could be improved through the use of a deception strategy designed to intentionally induce the Hawthorne effect. This effect is often cited as being responsible for oral health improvements of control groups that receive placebo treatments. It is thought that participating in and fulfilling the requirements of a study alters subjects' behavior, thereby contributing to the improvement. Forty patients with histories of poor oral hygiene were assigned, in a quasi-random fashion, to two groups. Experimental subjects (n = 20) were presented with a situation that simulated participation in an experiment. These included the use of a consent form; distribution of tubes of toothpaste labeled "experimental"; instructions to brush twice a day for two minutes using a timer; and a request to return unused toothpaste. Control subjects (n = 20) had no knowledge of study participation. Tooth surface area covered with plaque was used as a proxy measure of home care behavior. It was measured at baseline, three months, and six months. Mean percentages of tooth surface covered with plaque for the experimental and control groups were 71 (+/- 11.52) and 74 (+/- 11.46) at baseline; 54 (+/- 13.79) and 78 (+/- 12.18) at three months; and 52 (+/- 13.04) and 79 (+/- 10.76) at six months. No statistically significant difference ($p > .05$) was obtained between groups at baseline. Statistically significant differences ($p < .05$) were found between groups at three and six months. Significant differences ($p < .05$) were also found only for the experimental subjects between baseline and each of the two subsequent observation periods. The efficiency and potential effectiveness of this strategy suggest that additional research be conducted to assess oral health improvements and possible applications to the private practice setting.

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Bacterial plaque adheres to hard and soft oral tissues and, if not removed, can increase susceptibility to caries and periodontal infections.[1] Fixed orthodontic appliances provide additional surfaces that harbor plaque, further increasing the risk for caries, gingivitis, and periodontal disease. If unchecked, poor oral hygiene may jeopardize orthodontic treatment outcomes.[2] It is estimated that between 5 and 10 percent of orthodontic patients are unable to complete treatment for this reason.[3] While many strategies have been investigated to improve plaque control of orthodontic patients, few have shown success over the long term. However, in a variety of studies, researchers have attributed both long-[4-5] and short-term[6-8] oral health improvements to the influence of the Hawthorne effect as an unintended consequence of research participation.

It is difficult to ensure patient compliance with home care recommendations, and as a result, long-term treatments such as orthodontia often have only a 50 percent compliance rate.[9] Factors reported as associated with compliance include patient characteristics (e.g., mental and physical disabilities, beliefs and attitudes, history of noncompliance, parental influence); treatment complexity and duration (e.g., long-term prophylactic and/or complex regimens tend to have poor compliance); the relationship between the patient and provider (e.g., compliance sometimes is improved when the patient has a positive attitude toward the provider); and educational

and behavioral interventions used (e.g., rewards and education interventions); but none has consistently improved compliance, especially over the long term. Further, none of these factors has exhibited a consistent relationship with oral home care compliance for general dental or orthodontic patients.[10-14]

Unintended Outcomes of the Hawthorne Effect

The term "Hawthorne effect" commonly refers to any "unexplained result in an experiment on human subjects, on the assumption that the result occurred simply because the subjects were in an experiment and thereby experienced something that otherwise would not have affected them."[15] The effect is also recognized as a reaction of subjects to the realization they are in a study and are being observed.[16] Hawthorne was a Western Electric Company plant where studies were conducted between 1924 and 1932 examining the influence of different work environment variables on productivity. Some of these variables included rest pauses, duration of work, money incentives, and supervision. While the actual conduct of those studies is not relevant to this discussion, what is important is that the term "Hawthorne effect" has been used frequently to account for gains made by placebo control groups when none were expected. It is cited in the dental and medical literature.[4-5,7-8,17-20] In some studies, the Hawthorne effect has had a greater influence on the placebo control group than the experimental effect had on the experimental group. In a large number of instances, the Hawthorne effect yields statistically significant improvements for the control group over baseline. A summary of a very small subset of those studies appears in Table 1.[6,21-29]

Medical and dental studies have suggested that the Hawthorne effect alters the subject's behavior, thereby accounting for the improvement in the outcome variable.[4-5,7-8,17-19] In the context of oral health, this suggests that frequency, duration, and effectiveness of home care regimens (all behavioral in nature) might be improved if the Hawthorne effect could be intentionally induced. Therefore, the purpose of this investigation was to evaluate whether it would be possible to improve the oral home care of historically noncompliant orthodontic patients using a strategy that intentionally induces the Hawthorne effect. Specifically, this study evaluated whether subjects who were deceived into believing they were participating in a clinical trial would have lower plaque scores than those who were unaware that they were in a study.

Methods and Materials

This six-month study used a single-blind, quasi-random assignment, two group convenience design with forty active orthodontic patients (ages fourteen to eighteen) who had a record of poor oral hygiene. All subjects were recruited from the University of Missouri-Kansas City Graduate Orthodontic clinic. The study was approved by the University of Missouri-Kansas City Social Sciences Institutional Review Board.

Subjects

This convenience sample was obtained from the patients undergoing active treatment by four second-year graduate orthodontic residents. Each resi-

Table 1. Control group improvements attributed to Hawthorne effect versus experimental group improvements (over baseline %)

Study Variable	Experimental Group (Baseline-Posttest)	Control Group (Baseline-Posttest)	Author/Date
Oral hygiene	44% (plaque)	56% (plaque)	Aldridge et al., 1995[21]
Oral hygiene	49% (bleeding)	84% (bleeding)	Westfelt et al., 1998[22]
Toothpaste	9% (bleeding)	11% (bleeding)	Binney et al., 1996[6]
Toothpaste	31% (plaque)	35% (plaque)	Palomo et al., 1994[23]
Toothbrushing	29% (bleeding)	35% (bleeding)	Johnson and McInnes, 1994[24]
Mouthrinse	37% (plaque)	38% (plaque)	Beiswanger et al., 1990[25]
Mouthrinse	13% (plaque)	14% (plaque)	Kohut and Mankodi, 1989[26]
Oral hygiene	38% (plaque)	46% (plaque)	Lim et al., 1996[27]
Oral hygiene	10% (bleeding)	17% (bleeding)	Albandar et al., 1994[28]
Mouthrinse	32% (plaque)	27% (plaque)	Mankodi et al., 1992[29]

dent identified ten of his or her patients who satisfied the following inclusion criteria: brackets on teeth #6-11, 24, 25; a negative medical history; a record of "poor oral hygiene"; and fully erupted teeth #6, 7, 8, 9, 10, 11 (an explorable CEJ at gingival margin). Teeth #24 and #25 were substituted for those that were partially erupted. "Poor oral hygiene" was defined as a three-month history of greater than 50 percent of all facial tooth surfaces covered with plaque. Exclusion criteria included a history of inability to comply with the four- to six-week interval visits; medical history with cancer, lupus, pregnancy, allergies, or any condition that required pre-medication; sensitivity to fluoride toothpaste; and untreated caries or restorations on study teeth.

While the intention was to match subjects on type of toothbrush used (manual versus electric) and then to randomize to groups, the father of three sibling patients insisted that they all be in the same group. Those three were randomly assigned to the experimental group. All other patients were matched and randomly assigned as intended. This yielded an experimental group with ten males and ten females, along with a control group of sixteen males and four females. Two subjects in the experimental and three in the control group had teeth #25 and #26 substituted for non-erupted or missing anterior teeth. Toothbrush type was monitored for each subject throughout the study, and no changes occurred over the six-month period.

The influence of the unequal gender distribution in the two groups was evaluated using a factorial ANOVA with gender and group as the two independent variables and baseline plaque as the dependent variable. The final results indicated that there were no statistically significant differences for gender ($p > .05$). Consequently, despite the disproportionate number of males and females, there was no attempt to statistically control for this variable.

Procedures: Experimental Group

To induce the Hawthorne effect, subjects in the "experimental" group were told they were participating in an experiment examining the effectiveness of a new orthodontic toothpaste. First, subjects were approached during a regularly scheduled clinic visit, presented with an explanation of the study, and asked if they might be interested in participating. They were told that they were being recruited to participate in a study evaluating the ability of a new toothpaste (in reality, regular Crest with fluoride, Proctor & Gamble) that would improve the oral health specifically of orthodontic patients. If interested, the consent form that explained the study's purpose, risks and benefits, and subject responsibilities was provided to the subject and his or her parent or guardian. Following questions and answers, the patient and parent/guardian were asked to sign the consent form.

Subjects also were asked to complete the address portion of five postcard labels (to be used as mail reminders for upcoming visits); have their teeth disclosed and photographed for purposes of data collection to monitor their progress; given a two-minute brushing timer to be used at home; asked to brush twice a day for two minutes each; and given (by individuals not associated with the study) new tubes of "experimental" toothpaste at each regularly scheduled visit. All toothpaste was in an unmarked tube except for patient identifier number. This was consistent with the narrative in the consent form indicating that subjects would randomly receive either the experimental or placebo toothpaste, but would not know which because both would be dispensed in a plain unmarked tube. At the conclusion of the study, each subject and parent/guardian were debriefed and the deception and its rationale explained.

Control Group Procedures

Subjects in the control group were not asked to participate in any activity not normally associated with orthodontic treatment by their resident. All data collected from these subjects had been agreed to as part of the standard Orthodontic Clinic consent form signed by all patients. That consent allows for the standard collection of information related to the patient's oral health including the use of clinical photographs. Thus, these subjects should not have been sensitized to the possibility that collected data was being used for any purpose other than to monitor oral health progress.

Measurement of Oral Hygiene Compliance

The second author, a registered dental hygienist, collected all plaque accumulation data for this study and was blind as to group affiliation. This individual was not involved in making appointments, reminding patients of appointments, distributing materials, and so on. Further, patient identification throughout the study was maintained through the use

of a randomly generated identifier. In this way, blinding was maintained throughout the study.

All data was collected during regularly scheduled orthodontic appointments. Thus, each subject began and completed the study at slightly different times according to their orthodontic recall schedule (four weeks, six weeks, etc.). There was an average of fourteen weeks between baseline, three months, and six-month measurements.

Just prior to an orthodontic visit (at baseline, three months, and six months), each subject had six designated teeth disclosed with erythrosine and rinsed in preparation for clinical photographs. Cheek retractors were used to retract the lips and cheeks, and the disclosed teeth were dried with an air/water syringe to remove excess saliva. Each subject was asked to place the teeth "edge to edge" so that all disclosed teeth were visible to the photographer. Three standardized digital photographs were taken (right lateral for teeth #6 and 7; frontal for teeth #8, 9, 24, and 25; left lateral for teeth #10 and 11) fourteen inches from each patient's disclosed teeth. Each photograph was marked with a unique code that could not be traced to any subject. The code was broken only after all data had been collected and prepared for statistical analysis.

The ratio of disclosed plaque to total tooth surface was calculated using a computer software program (Optimas from Media Cybernectics, Meyer Instruments, Inc., 1304 Langham Creek, Suite 235, Houston, TX 77084). Digital photographs were downloaded to a zip disk. Each file was labeled with the subject's code and the month the photographs were taken, then saved to one of forty files (one for each subject). Each tooth, bracket on the tooth, and disclosed plaque were outlined with the computer's mouse. The software automatically subtracts the bracket area from total tooth area and calculates the remaining area. Similarly, it then calculates the area in millimeters of disclosed plaque and finally reports a ratio.

Data Analysis

Intrarater reliability was evaluated by outlining the tooth surfaces, brackets and wires, and disclosed plaque according to software requirements for each of ten photographs twice on two separate days. Using the Pearson Correlation, the intrarater reliability was determined to be .998. A t-test was used to determine if a statistically significant difference existed between the two groups for plaque at baseline. A repeated measures ANOVA ($p < .05$) was used to assess the plaque scores within and between groups at all time intervals, and the Fisher-Hayter multiple comparison procedure ($p < .01$) was used for post hoc comparisons. The more conservative p value was used because of the number of possible comparisons.

Results

Nineteen (ten control and nine experimental) appointments were either not kept by the subjects or rescheduled by the orthodontic clinic due to uncontrollable circumstances. Two subjects (one experimental and one control) did not have six-month data collected because their appliances were removed early, but not due to oral health reasons. One subject finished orthodontic treatment ahead of schedule, and the other needed appliances removed prior to unexpected heart surgery. Thus, six-month data was available for thirty-eight subjects—nineteen in each group.

There was no plaque score difference between groups at baseline ($p > .05$). Means and standard deviations for tooth surface covered with disclosed plaque for the experimental and control groups respectively were 71 percent (+/- 11.52) and 74 percent (+/- 11.46) at baseline; 54 percent (+/-13.79) and 78 percent (+/- 12.18) at three months; and 52 percent (+/- 13.04) and 79 percent (+/- 10.76) at six months. The repeated measures ANOVA showed statistically significant differences ($p < .05$) between and within groups. These results are summarized in Table 2. The Fisher-Hayter multiple comparison procedure found statistically significant differences between groups at both three and six months ($p < .01$) and statistically significant improvement for only the experimental group from baseline to three months and baseline to six months ($p < .01$).

Discussion

In this study the intentional use of the Hawthorne effect improved oral hygiene compliance of adolescent orthodontic patients who previously had exhibited poor oral health. The Hawthorne effect was intentionally induced by deceiving subjects into believing they were participating in a toothpaste study. For these experimental subjects, mean plaque scores were 71 percent at baseline, 54 percent at three months, and 52 percent at six months. On the other

Table 2. Between subjects (groups) and within subjects (time) mean plaque score percentages for baseline, three months, and six months

Group	Baseline (%)	Three months (%)	Six months (%)
Experimental (n = 19)	71 (+/- 11.52)	54 (+/- 13.79)	52 (+/- 13.04)
Control (n = 19)	74 (+/- 11.46)	78 (+/- 12.18)	79 (+/- 10.76)

hand, the control group plaque scores were 74 percent at baseline and rose to 78 percent at three months and 79 percent at six months. Since the dentifrice used was an over-the-counter fluoride product, the improvement in plaque scores can only be attributed to the Hawthorne effect—that is, a change in home care behavior as a consequence of believing one is participating in an experiment. These results are consistent with literature showing that subjects who are aware of their participation in an investigation alter their behavior. This study demonstrates that, when used intentionally, the Hawthorne effect can alter subjects' oral health behavior.[4-6,21-29]

It is also important to note that plaque accumulation increased slightly for only two subjects and decreased for all others in the experimental group. All subjects in the control group experienced the same or increased plaque accumulation. It is clear, therefore, that behavior changes as evidenced by removal of plaque by toothbrushing were apparent for the experimental but not the control group.

Because the Hawthorne effect imposed in this manner is time-efficient, it may be possible to apply the technique in private dental practice. All that is required is that the subject be convinced that he or she is being enrolled in a "study." If adapted for use in the practice of orthodontics, this approach would require a small investment in time at the outset to obtain "informed consent" and engage in the other activities normally associated with a real investigation. Additional time would be spent collecting data (i.e., clinical photographs) and holding a debriefing session at the conclusion of the "study." It is not suggested that this approach be used with all orthodontic patients, but it might be beneficial for those who stubbornly refuse to improve home care and for whom premature removal of appliances is a real possibility.

While the results of this study were encouraging, there were some limitations. For example, even though the experimental group showed statistically significant improvement in plaque scores, it is unknown whether improved oral health was achieved. Pocket depths and bleeding indices were not taken, so measurement of attachment loss and inflammation could not be determined. These would be better indicators of periodontal infection. Still, the presence of bacterial plaque mass increases the risk of gingivitis although its relationship with loss of periodontal attachment is less clear.[30] Thus, additional studies should be conducted that include the use of oral health indices to evaluate if the improvements experienced in this study would translate to improved bleeding points, gingival inflammation, pocket depth, and gingival fluid flow.

It is also unknown whether the Hawthorne effect can be sustained longer than a six-month period. Therefore, at least a one-year time frame is warranted for future studies using orthodontic patients who need to adequately remove plaque around appliances over an average of 20.2 months[20] and for periodontal patients who must maintain or decrease periodontal pockets throughout their lifetimes.

Further studies should be conducted to evaluate the usefulness of the Hawthorne effect on other dental populations (restorative and periodontal). For example, a dentist or hygienist could use a "new" or "experimental" toothbrush, toothpick, or floss to test its effect on gingival health, or implement a "new" mouthwash for periodontal patients to reduce gram negative bacteria. Since the Hawthorne effect is efficient to implement for the practitioner, it may be an ideal method to improve oral hygiene for those patients where traditional interventions (oral hygiene instructions and praise) have failed. From a psychological perspective, it would be interesting to evaluate whether after a period of time during which the Hawthorne effect was producing a beneficial outcome, if subjects could be debriefed and encouraged to continue applying the newly learned oral health habits.

All these issues aside, the question still remains whether this form of deception is ethical. In the context of research, determining whether risks such as those that may be a consequence of deception are "minimal" and determining whether the potential benefits outweigh those risks constitute the gold standards of ensuring patient safety. The other standard includes informed consent, which was impossible in this study without jeopardizing its purpose. Thus, it

is required that subjects be debriefed, so that the deception and its rationale are explained at the conclusion of the study.[31] In the context of this study, risks were deemed to be minimal. The debriefing sought to help subjects and their parents/guardian understand the true purpose of the study including the notion that subjects clearly improved their home care with the possible consequent improvement in oral health. In short, it was possible that these particular subjects could suffer greater risk in the form of oral disease and early removal of appliances, had they not participated in the study.

In clinical practice the form of deception used in this study may be viewed as paternalism. A clinician who seeks to prevent harm or to bring about good for the patient in the absence of serving the clinician's best interests is being paternalistic but not necessarily unethical.[32] If the clinician clearly explains the consequences of poor home care and how that home care can be accomplished and if the patient still does not adopt appropriate behaviors, a deception in the best interest of the patient is not unwarranted, especially if the consequences outweigh the risks of the deception. Further, when this is coupled with a debriefing at an appropriate time for all patients or a briefing with parents of minors prior to the deception, there is no ethical lapse.

Conclusions

Within the limitations of this study, it may be concluded that:

- When used intentionally, the Hawthorne effect can improve oral hygiene compliance in orthodontic patients as measured by plaque scores;
- The Hawthorne effect can have an effect on patients' behavior that lasts as long as six months; and
- The use of the Hawthorne effect may be time-efficient for the dental practitioner.

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