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Establishing effective dental care

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VERBAL REGULATION OF BEHAVIOUR IN CHILDREN:
Establishing Effective Dental Care.

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SUMMARY

This thesis investigates rule-governed behaviour in children within the practical domain of dental care. Eight experiments were conducted to examine how rules, contingencies, and environmental cues, could be employed by parents to empower six year old children to improve their toothbrushing behaviour. Multiple baseline across subjects designs were employed in each experiment. In order to maximize ecological validity and long-term maintenance of behaviour change, (i) all observations were conducted in subjects' homes, (ii) behaviour was recorded by video cameras, and (iii) parents administered the interventions.

Experiments 1 and 2 examined the effectiveness of a 'correspondence training' and a 'compliance training' method, respectively. Both procedures increased considerably the frequency and durations of toothbrushing: no apparent differences were noted in the efficacy of the two procedures during training or follow-up phases. Experiments 3 and 4 investigated the effects of incorporating a stimulus control device into the compliance training procedure. The introduction of this device, which provided visual and auditory guidance for the children, showing where to brush and for how long, led to additional large increases in (i) children's durations of toothbrushing, and (ii) the number of locations (tooth surfaces) brushed. Experiments 5 and 6 examined methods designed to improve maintenance by making the 'natural' consequences of toothbrushing more frequently and immediately apparent to the children. A disclosing agent (erythrosine) revealing plaque on children's teeth was introduced into the procedures, and parents were taught to 'score' dental hygiene. Rewarding increases in hygiene 'scores' led to substantial improvements in toothbrushing, but long-term maintenance was not better than in previous procedures. Experiments 7 and 8 investigated the components of the treatment package, and found that similar effects could be generated with less parental intervention and fewer material rewards.

The results showed that employing rules, cues and contingencies can be a very effective means of enabling children to alter their behaviour.

CONTENTS

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

1.1. PREAMBLE

The major purpose of this thesis is to examine some important theoretical issues in the field of behaviour analysis within a 'real-life' practical domain. Recently, the so-called 'language hypothesis' (Lowe, 1979) has led several researchers to conclude that some of the observed differences between human and animal learning could in a large measure be attributable to the effects of verbal events on human action. The current work examines the relationships between verbal behaviour (what parents say to children, or children say to themselves) and non-verbal action (what children do) in the context of dental care.

The thesis consists of six chapters. This, the first, is an introduction and review of the relevant literature; the middle four chapters describe the methods and results of the eight experiments (two in each chapter) that were designed to address a variety of issues, both theoretical and practical, that arise from previous research and the present studies; the final chapter presents the conclusions.

The first section of the current chapter will (i) outline the development of the behaviour analytic perspective that has influenced the design of the experiments and the interpretation of the results, and (ii) briefly describe some findings from previous research in the area of dental health promotion. The next four sections of Chapter 1 will present a review of the literature that has had an important effect upon the development of the current research.

The theoretical perspective taken in this thesis has been influenced primarily by the science of behaviour analysis and the philosophical position of B. F. Skinner (to be discussed in this section), and secondly by the school of Soviet psychology, particularly the work of L. S. Vygotsky and his followers (discussed in Section 1.2. "Development of Verbal Regulation"). Both of these approaches can trace their historical roots back to a book by Ivan Mikhailovich Sechenov entitled *Reflexes of the Brain*, originally published as two journal articles in 1863. This work, in which Sechenov proposed that *all* psychological activity is the result of environmental stimulation, heralded the establishment of an objective science of psychology (McLeish, 1975). It led quite directly to Pavlov's work on higher nervous activity ('behaviour') and the foundation of Soviet psychology. Sechenov's and Pavlov's work also inspired the birth in America of a philosophy that became known as behaviourism, and this led in turn to the development of the scientific method now known as behaviour analysis.

In 1913, the American psychologist John B. Watson launched behaviourism with the publication of a series of lectures entitled *Psychology as the Behaviorist Views it.* Watson rejected the concept of mind and advanced the view that psychology should be restricted to the study of behaviour (the activities of people and animals). He believed that the goal of psychology should be 'the control and prediction of behaviour', and argued passionately that psychology should be relevant to real life. Watson's hope was that from the application behavioural principles (at that time based mostly on Pavlovian conditioning) would grow a 'powerful technology of behaviour change' with which the human social condition could be radically improved (Watson, 1924). In the 1950's, with his work on operant behaviour, B. F. Skinner emerged as the leading exponent of behaviourism and remained so until his death in 1990. Skinner was committed to a psychology based on scientific principles, and made many practical and theoretical contributions to the study of behaviour, but like Watson, he was not content to see behavioural principles confined to the laboratory.

Early behaviour analytic research in the laboratory showed that animal behaviour can be analysed within the framework of the 'three term contingency', that is with reference to the relationship between responses, reinforcers and discriminative stimuli. Since then behaviourists have amassed, over several decades, a huge body of data concerning patterns of responding induced by various schedules of reinforcement. These data, predominantly from non-human subjects, show that the effects are orderly and generally replicable within and across animal species. Many researchers have claimed, therefore, that the basic operant principles can be applied with equal success to both animals and humans (e.g. Morse, 1966; Rachlin, 1974, 1980).

Behaviour analysts, influenced by Skinner, were always keen to see the findings of their research applied to human problems. Clinical and educational psychologists seized upon the literature from the animal laboratories because of the promise not only of an explanatory system, but more importantly for them, the means to change behaviour (Lowe, 1983). It appeared that since the basic conditioning principles were well established, all that remained was the development of an appropriate technology for their application in clinical, educational, and other social settings.

However, despite the early confidence of behaviour analysts, the prediction and control of complex human behaviour has proved elusive. The application of behavioural principles derived from models of animal learning has been shown to have serious limitations, and the 'powerful technology of behaviour change' has not materialized (Lowe, Horne & Higson, 1987). This may not appear surprising given that Skinner himself had warned as early as 1938 that:

> "The importance of a science of behaviour derives largely from the possibility of an eventual extension to human affairs... Whether or not the extrapolation is justified cannot at present be decided. It is possible that there are properties of human behaviour which will require a different kind of treatment. But this can be ascertained only by closing in on the problem in an orderly way and by following the customary procedures of an experimental science." (Skinner, 1938).

What is surprising, however, is that despite Skinner's proposal that the validity of extrapolating from animals to humans can be tested only by the systematic experimental investigation of both animal and human behaviour, very little research of this kind was reported before 1980.

Operant research has now shown, however, that human behaviour, when subjected to scheduled reinforcement, differs in fundamental respects to the behaviour of other animal species (Bentall & Lowe, 1987; Bentall, Lowe & Beasty, 1985; Horne & Lowe, 1993; Leander, Lippman, & Meyer, 1968; Lippman & Meyer, 1967; Lowe, Beasty & Bentall, 1983; Lowe, Harzem & Bagshaw 1978; Lowe & Horne, 1985; Weiner, 1969). The differences appear so great that many researchers now doubt the value of theories of human learning that are based on the animal learning literature. Some authors have claimed even that there is no convincing evidence for either classical or operant conditioning in humans (see Brewer, 1974).

> "Recently, behaviorists themselves have soul-searched (cf. Brigham, 1980; Cullen, 1981; Michael, 1980; Branch and Malagodi, 1980; Repucci and Saunders, 1974), outsiders have been eager to announce behaviorism's demise (Mackenzie, 1977), and out of the disillusionment the hydra-headed monster of mentalism, once thought to be subdued by Watson and finally despatched by Skinner and Ryle, has resurfaced in the form of contemporary cognitivism." (Lowe, 1983, p.73).

Cognitive psychology has emerged during the last twenty years as a dominant force in western psychology. Psychologists working in applied fields have begun to turn away from behaviourism and to look instead towards cognitive psychology for behaviour change strategies (see for example, Beck, 1970; Ellis, 1973; Meichenbaum & Goodman, 1971). A major criticism was that behaviour analysts had not provided an adequate account of the effects of instructions and verbal rules on human behaviour. Researchers from outside the field proposed that an analysis of human consciousness, language and thinking lay "beyond the conceptual limits of behaviorist psychological theory" (Chomsky, 1972, p.72). However, the two scientists, Pavlov and Skinner, who have most influenced behaviourism, both stressed the biological and psychological commonalities of humans and other animals, but also noted the differences between human and animal consciousness:

> "When the developing animal world reached the stage of man, an extremely important addition was made to the mechanisms of the nervous activity. In the animal, reality is signalized almost exclusively by the stimulations and by the traces they leave in the cerebral hemisphere, which come directly to the special cells of the visual, auditory or other receptors of the organism .... This is the first system of signals of reality common to man and animals. But speech constitutes a second signalling system of reality which is peculiarly ours, being the signal of the first signals. On the one hand, numerous speech stimulations have removed us from reality. On the other hand, it is precisely speech that has made us human ...... " (Pavlov, 1927).

> "Other species (than humans) are ...... conscious in the sense of being under stimulus control. They feel pain in the sense of responding to painful stimuli, as they see light or hear a sound in the sense of responding appropriately .... A person becomes conscious in a different sense when a verbal community arranges contingencies under which he not only sees an object but sees that he is seeing it. In this special sense consciousness or awareness is a social product." (Skinner, 1974, p.220).

In much of his theoretical writing Skinner has emphasized the importance of verbal behaviour (both overt and covert) as a determinant of other behaviour. In *About Behaviorism* (1974) he noted that verbal behaviour has a special character "because it is reinforced by its effects on people - at first other people, but eventually the speaker himself. As a result, it is free of the spatial, temporal, and mechanical relations which prevail between operant behavior and nonsocial consequences" (p.89) Of private events (thoughts) Skinner writes "What is inside the skin, how do we know about it? The answer is, I believe, the heart of radical behaviorism" (p.212).

Although behaviour analysts (e.g. Bijou & Baer, 1961; Keller & Schoenfeld, 1950; Skinner, 1953) have written about cognition and the various kinds of behaviour subsumed under this general term (e.g. thinking and problem solving) for over 40 years, the majority of behaviour analysts have, until only recently, contented themselves with detailed studies of animal behaviour, and did not engage in the study of humans at all. Of those who did engage in human operant research, most attempted to isolate and eliminate any effects of the so-called higher psychological processes (Vaughan, 1989). Within the last decade, however, many researchers appear to have concluded that behaviour analysis has reached a point where direct basic research on human action is possible, respectable, and of fundamental importance (Hayes, 1989). Whereas Skinner (1972) rightly argued that "we cannot discover what is 'essentially' human until we have investigated nonhuman subjects" (pp.201-202), Lowe

(1983) has emphasized the corollary that "we cannot discover what is essentially human until we have also investigated humans" (p.84).

Human research has now begun to assume a centrally important role within basic behaviour analysis. No longer is it simply a means of testing the generality of findings from non-human subjects. Instead it has become a means for constructing an empirically based behaviour analytic account of language and its impact on other behaviour. New and exciting research methods, findings and theories have emerged that are quite unlike stereotypical views of behaviour analysis (Hayes & Hayes, 1992). There has been a great surge of interest in topics that were once considered outside the scope of behaviour analysis. For example, behaviour analysts have begun to attempt to provide accounts for the development of word meaning, verbal rules and verbal regulation. They have gone beyond the speculations of Pavlov and Skinner, and have begun to examine experimentally the essence of human consciousness and self-control. "In short, behavior analysis is now a field actively studying 'cognition'" (Hayes & Hayes, 1992, p.1393).

The research described in the current thesis is an attempt to extend the behaviour analytic literature on verbal regulation. More specifically it examines the environmental conditions necessary to bring behaviour under the control of verbal rules in a 'real-life' practical domain. The domain chosen for this research is that of dental health promotion. This is an area that is relevant to every human being, since almost all of us are likely to suffer from dental diseases that we ourselves are able to prevent. To be effective, however, dental self-care behaviours must be practiced daily, and perhaps because the consequences of each instance of behaviour are not immediate and sizable, but rather are cumulative, many of us fail to do what is necessary.

There are only two major dental diseases, dental caries (tooth decay) and periodontal (gum) disease. Dental caries has increased in prevalence during the last 200 years to become a major health and social problem. Its peak incidence is during childhood. In the United Kingdom 48% of 5 year olds and 93% of 15 year olds are affected by dental caries. Periodontal disease (gingivitis) is a condition which usually begins in childhood, and increases in severity through early adulthood to middle age. Although severity varies greatly, about 95% of the adult population exhibit this condition to some degree (Health Education Council, 1986). Dental plaque is a soft bacterial deposit that grows quickly and clings to the teeth. The presence of plaque is necessary for both caries and gingivitis to develop, and research has shown that without plaque, cavities fail to develop even with frequent additions of sucrose to the diet (Loe, 1970; "Plaque", 1984). Recent research has shown that almost all dental disease is preventable by simple behavioural changes (Blinkhorn, Fox & Holloway, 1988).

> "The single most important oral hygiene measure is toothbrushing. The available evidence indicates that it is the result of toothbrushing which matters most and, provided that plaque is removed effectively and regularly without causing damage, the precise method is less important.

Above all, toothbrushing skills should be taught to people of all ages." (Levine, 1986, p.6).

Significant improvements in the incidence of periodontal disease are possible with intensive programmes for thorough plaque removal (e.g. Horowitz, Suomi, Peterson *et al.*, 1976). The toothbrush, even without toothpaste, can remove major amounts of supragingival dental plaque (the direct cause of gingivitis) and is the single most effective dental therapeutic device (Levine, 1986; Pader, 1987). Studies have indeed demonstrated that well executed toothbrushing improves gingival condition, whether gingivitis is induced experimentally by short-term abstinence from oral care, or is the result of long-term oral factors (Graf, Mair & Graf, 1984; Wunderlich, Caffesse, Morrison, Temple & Kerschbaum, 1984). Thorough and frequent toothbrushing has also been shown to reduce the incidence of caries (i) through the plaque removing action of the brush (Fogels, Cancro, Bianco & Fischman, 1982; Gershon & Pader, 1972; Hein, 1954), and (ii) because of the delivery of benefits from fluoride toothpastes (Duckworth, 1968).

Although toothbrushing behaviour is common and most people claim to practice a daily toothbrushing routine, the majority do not brush effectively every day (Bedi, Sutcliffe & Balding, 1989; Todd & Dodd, 1985). A number of reports have shown that toothbrushing behaviour is determined by a different set of factors than other dental health behaviours (e.g. fluoride rinsing, interdental cleansing) designed to prevent dental disease (Humphris, 1987; Traen & Rise, 1990). Characteristically these studies indicate toothbrushing to be a behaviour which has become habitualized and performed virtually automatically by the time individuals have reached adolescence. It is important, therefore, that dental health educators focus attention on the early formation of toothbrushing practices.

Health education can be defined as "any combination of learning opportunities designed to facilitate voluntary adaptions of behaviour which are conducive to health" (Green, 1979). Several studies have shown that attempts to alter toothbrushing habits through health education have met with little success (see Gatherer, Parfit, Porter & Vessey, 1979) Traditionally, health education programmes rely upon the provision of information about dental disease and methods of prevention. Studies evaluating such programmes have shown that although they are often successful in improving knowledge (what people say), they are rarely successful in bringing about changes in oral hygiene behaviours (what people do); how changes in people's expressed opinions about dental health affect behaviour is largely unpredictable in both direction and duration (Hunt & Martin, 1988). The key issue then is how not only to change what people think or say to themselves or others, but also to ensure a correspondence between what they say and what they do. Locker (1989) concludes:

> "The main lesson to be learned from these efforts is that knowledge is a necessary but not sufficient factor in changing oral health practices. Clearly, the transmission of information and skills needs to be

supplemented by other strategies if more permanent behaviour change is to be accomplished." (Locker, 1989, p.164).

For years dentists have tried various approaches designed to encourage young children to brush their teeth effectively. To be maximally effective, dental hygiene programmes should result in effective brushing over long periods of time. However, since oral hygiene programmes have produced, more often than not, only very short term effects, an effective programme for teaching dental hygiene to young children is greatly needed (Blount, Baer & Stokes, 1987) . The early implementation and maintenance of effective toothbrushing habits at home would have obvious future health benefits.

"Caries and periodontal diseases tend to be slowly developing chronic conditions. The appropriate preventive behaviours must be practiced continually through the years, often in the absence of clear feedback or consequences. Furthermore, the diseases to be prevented are not perceived as life-threatening. In view of these facts, it is not surprising that increasing acceptance of oral behaviours poses a considerable challenge." (Silversin & Kornacki, 1984, p.145).

The practical objective of the current research was to examine the determinants of children's toothbrushing behaviour, and to develop an effective behaviour change strategy, that can be implemented by any parent, to promote important beneficial changes in the toothbrushing behaviour of young children. The behaviour change strategy was designed to facilitate the transition from parent-directed behaviour to *'self-initiated toothbrushing'* in the parents' absence, and to ensure that the *'quality of toothbrushing'* was maintained at a level that would be considered adequate by the dental profession.

The theoretical questions addressed in this thesis are: What environmental and verbal factors are important for bringing children's toothbrushing under stimulus control? How does what children say about toothbrushing affect what they do? How does what parents say about toothbrushing affect what children do? How is the relationship between 'saying' and 'doing' affected by environmental consequences? The following sections of this chapter examine the relevant literature relating to these issues.

1.2. DEVELOPMENT OF VERBAL REGULATION

Although behaviourism and Soviet psychology have a common scientific origin (the work of Sechenov and Pavlov), they have developed quite divergent characters. Behaviour analysts have begun from a premiss succinctly described by Skinner.

> "There are excellent reasons for beginning with simple cases and moving on only as the power of analysis permits. If this means, as it seems to mean, that one begins with animals, the emphasis is no doubt upon those features which animals and people have in common. Something is gained, however, since only in this way can we be sure of what is uniquely human ...... That is the direction - from simple to complex - in which science moves." (Skinner, 1974, pp.226-227).

Soviet psychologists, on the other hand, have proceeded to the direct examination of the development of psychological functions in humans. In 1924, Lev Vygotsky, a contemporary of both Watson and Pavlov, began to develop a different set of tools to those currently used by the behaviourists; he began to develop what has become known as 'socio-historical psychology'. Sechenov had proposed that all psychological activity is the result of environmental stimulation. Vygotsky's approach, on the other hand, was more 'dialectical'; he rejected the simple animal models of human behaviour much employed by behaviourists.

> "Using current methods, we can only determine quantitative variation in the complexity of stimuli and in the responses of different animals and humans at different stages of development. It is my belief, based upon

a dialectical materialist approach to the analysis of human history, that human behaviour differs qualitatively from animal behaviour to the same extent that the adaptability and historical development of humans differ from the adaptability and development of animals. The psychological development of humans is part of the general historical development of our species and must be so understood. Acceptance of this proposition means that we must find a new methodology for psychological experimentation........ The dialectical approach, while admitting the influence of nature on man, asserts that man, in turn, affects nature and creates through his changes in nature new natural conditions for his existence. This position is the keystone of our approach to the study and interpretation of man's higher psychological functions and serves the basis for the new methods of experimentation and analysis that we advocate." (Vygotsky, 1978, pp.60-61)

It was Vygotsky (with Alexander Luria, Alexei Leontiev and others) who made the first significant contributions to our understanding of the development of verbal regulation. Central to Vygotsky's approach was the role of language in the development of human consciousness. Vygotsky proposed that language is shaped by the culture within which it develops, and it is a tool of thought that shapes thought itself (Minick, 1987). Vygotsky's explanation of the origin of the 'higher psychological functions' included two components. First, he argued that these higher psychological functions rely on the mediation of behaviour by signs and sign systems, the most important of which is speech. Vygotsky saw speech as a special type of stimulus that is used as a psychological tool which is "directed toward the mastery or control of behavioural processes, either someone else's or one's own, just as technical means are directed toward the control of nature", and "the psychological tool alters the entire flow and structure of the mental functions ...... by determining the structure of the new instrumental act" (Vygotsky, 1981). Second, Vygotsky argued that it is in social interaction, in behaviour that is being carried out by more than one individual, that speech first functions as a psychological tool. The individual participates in social activity mediated by speech, by tools that others use to influence his behaviour and that he uses to influence the behaviour of others. Subsequently, the individual "begins to apply to himself the same forms of behaviour that were initially applied to him by others." (Vygotsky, 1987, p.21).

As early as 1926 Vygotsky and his colleagues began to apply their new methods to the examination of how a child's behaviour is 'restructured' through the introduction of external speech, and to explore how this behaviour is internalized. They advocated an 'experimental-developmental' approach that aimed to artificially provoke or create a process of psychological development. The emphasis was on the process of change, because Vygotsky believed that "it is only in movement that a body shows what it is."

> " .... in psychology we often meet with processes that have already died away, that is, processes that have gone through a very long stage of historical development and have become fossilized. These fossilized forms of behaviour are most easily found in the so-called automated or mechanized psychological processes which, owing to their ancient origins, are now being repeated for the millionth time and have become

mechanized. They have lost their original appearance, and their outer appearance tells us nothing whatsoever about their internal nature. Their automatic character creates great difficulties for psychological analysis." (Vygotsky, 1978, p.63)

Conventionally, the purpose of an experiment is to determine the conditions that control behaviour. An experimenter's primary goal is to produce a particular outcome in conditions that maximize interpretability. Vygotsky's methods were not simply derived to suit this purpose, but rather they flowed from his theory of the nature of higher psychological processes. He believed that if higher psychological processes arise and undergo changes in the course of learning and development, psychologists can only fully understand them by determining their origin and studying their development.

Vygotsky and his colleagues devised experiments that elucidated processes that are ordinarily hidden beneath the surface of habitual behaviour. By providing maximum opportunity for the subject to engage in a variety of activities that can be observed, but not rigidly controlled, these experiments served as an effective means of studying the process of development. One technique used for this purpose was to introduce obstacles or difficulties into a task that disrupted routine methods of problem solving. For example, in studying children's communication and the function of egocentric speech researchers set up a task situation that required children to engage in co-operative activity with other members of a group who all spoke different languages. Another method was to provide alternative routes to problem solving, including a variety of materials and instructions ("external aids") that could be used in different ways to satisfy the demands of the task. By carefully observing the uses made of these external aids by children at different ages during tasks of varying difficulty, Vygotsky and colleagues were able to reconstruct the series of qualitative changes in behaviour that normally unfolds during the course a child's development. A third technique was to set a problem that was too difficult for the child to solve at her current stage of development. The aim here was to examine the rudimentary beginnings of novel behaviours.

Vygotsky proposed that the development of verbal regulation is determined by a "sociohistorical process". Luria, after reviewing 30 years of Soviet psychological experimentation under Vygotsky's influence, presented an outline of "the long path of development of the regulatory role of speech in the formation of the child's behaviour", and concluded:

> "Indeed, the child, physically linked to his mother when in the womb and still biologically dependent on her during infancy, remains socially bound up with her for a long time. He is linked to her at first directly and emotionally, and later through speech; by this means he not only enlarges his experience but acquires *new modes of behaviour* and then *new ways of organising his mental activities.* By naming various surrounding objects and giving the child orders and instructions, his mother shapes his behaviour. Having carefully observed the objects named by his mother, after he acquires the faculty of speech, the child begins to name them *actively* and thus to organize the acts of his

perception and his deliberate attention. When he does as his mother tells him he retains the traces of verbal instructions in his memory for a long time. Thus he learns how to formulate his own wishes and intentions independently, first in externalized and then in inner speech. He thus creates the highest forms of purposive memory and deliberate activity. What he could previously do only with adult help, he is now able to do unassisted. This fact becomes the basic law in a child's development." (Luria, 1961, p.2).

Luria identified several basic stages in the development of the regulatory function of speech. First, the "impellant or initiating function of speech" may begin to develop soon after the child's first birthday. A child of eighteen months will respond appropriately to instructions such as 'clap hands' etc., but "although the adult's speech has already assumed an initiating function, it cannot yet inhibit an action once started, much less *switch the child from one action to another*." In one experiment, when children aged twenty to twenty-four months were told to put rings on a bar, they were able to do so, but if while they were busy on this task they were instructed to "take them off", it was found that the children could not comply. In fact, the effect of the new instruction was to increase the rate putting the rings *on* the bar!

Experiments with three-year-olds have shown that children at this age exhibit a more sophisticated level of development. When instructed to press a rubber bulb only in the presence of a green light, these children improved their performance when they used their own speech to accompany their behaviour. At this stage, however, it appears to be the *act of speaking* and not *what is spoken* that has the principal effect: when the instruction was "press twice", performance improved when the children said "Go! Go!", but not when they said "I shall press twice". Similarly when the instruction was "Press on every third signal", and the children said "Press - don't press - don't press" the effect was to increase errors dramatically (i.e. the children tended to press every time they spoke, irrespective of whether they said "press" or "don't press").

Luria suggests that the third stage, when children will respond appropriately to even a complicated instruction such as "Press in response to the first signal and don't press in response to the second", is not reached by most children before they are more than four years old. According to Luria, a child at this stage is able to regulate behaviour by "internally retained verbal rules".

> "The 'impellant' action of speech recedes into the background and the leading role passes to the regulatory influence of the significative connections produced by speech ...... the external developed forms of speech become reduced, and the decisive influence is now exerted by that higher form of internal speech which constitutes an essential component of both thought and volitional action...... This formation of internal speech, which is closely bound up with thought, leads to a new specifically human, stage of development ...... the child orients himself to the given signals with the help of the rules he has verbally formulated for himself; this abstracting and generalizing function of speech mediates the stimuli acting upon the child and turns the process of

elaboration of temporary connections into the complex, 'highest self-regulating system'" (Luria, 1961, pp.61-62).

The findings of the research reviewed by Luria have informed a series of behaviour-analytic studies conducted at Bangor to examine patterns of responding, and sensitivity to schedule parameter with human subjects on various fixed interval schedules of reinforcement (Bentall, Lowe & Beasty, 1985; Bentall & Lowe, 1987; Lowe, Beasty & Bentall, 1983). These studies show that preverbal infants (less than one year old) perform in a manner that is consistent with the animal data. Children older than five respond in one of two distinctive ways that are common with adult human subjects (i.e. they respond at a consistently high rate or a consistently low rate, and in either case their responding appears to be quite insensitive to the schedule parameters). Two to four year-old children, on the other hand, respond in ways that are neither characteristic of adult humans nor infants and non-human subjects.

> "These studies lend support to the hypothesis that the development of verbal repertoires greatly alters human operant performance, and this accounts for many of the differences found between animal and human learning. These findings are also consistent with research into the development of verbal self-regulatory skills in children, which suggests that the capacity to 'regulate' by means of speech is not well developed before the third or fourth year of life." (Bentall & Lowe, 1987, p.177).

Bentall and Lowe's (1987) final study in this series was designed to examine the uses made of instructions ("external aids") by children at different ages. Vygotsky noted that children at different stages of development vary not only in their ability to solve problems without adult assistance, but also in their ability to make use of prompts and instructions provided by their adult teachers. The difference between what a child can do alone and the limit of what the child can achieve through dialogue with a teacher has become known as "the zone of proximal development" (Vygotsky, 1978). Bentall and Lowe (1987) postulated that if the self-regulatory skills of a two to four year-old subject were still developing, though not fully acquired, then appropriate instructions to this child might produce a schedule performance that was characteristic of older children and adults, provided that the skills required were within the subject's "zone of proximal development". In this experiment two groups of children, divided into three age ranges (two and a half to four, five to six and a half, and seven and a half to nine years), were exposed to fixed-interval 40-s schedules. One group was instructed to respond at a high rate, and the other at a low rate, both groups were subsequently taught to provide their own spoken instructions that were consonant with the earlier experimenter-supplied instructions. The two to four year-old subjects, like the older children, who were given high rate instructions (once at the beginning of the first session) responded at a very high rate in every session for five to seven days. The two to four year-olds given low rate instructions were less able to inhibit responding than the older children, although they "gave every indication in the early stages of the study that they tried to comply with the instructions but could not refrain from responding" (p.188). When provided with a self-instructional strategy, which involved singing a nursery rhyme before saying "press" and making the response, the performance of the two to four year olds became similar to that of the older children given low rate instructions.

These findings are consistent with those reported by Luria (1961) indicating that most children do not achieve effective verbal regulation of behaviour by their own speech in terms of what it conventionally 'means' before they are four years old. The results confirm Luria's reports that although the "impellant or initiating function of speech" develops early, a child cannot use speech to inhibit action (e.g. produce a low rate of responding on the FI 40-s schedule) until a later stage of development, or without adult assistance (instruction). The data clearly exemplify Vygotsky's concept of "the zone of proximal development", and provide further evidence to support Luria's observation that it appears to be the *act of speaking,* and not the *meaning of what is spoken* that has the principal effect on the behaviour of three year-olds, or, as Bentall and Lowe put it:

> "The 'sing-and-press' self-instructional strategy that was then introduced did produce the low-rate pattern but it is important to note that none of the older children in this or previous studies spontaneously emitted verbal behavior of this type. The low-rate pattern that subsequently emerged could be a simple response chain (i.e., sing-respond) and, therefore, it should not be concluded that these children's singing bore the same functional relation to lever pressing as did the verbal behavior of the older children." (Bentall & Lowe, 1987, p.188).

Soviet psychologists, influenced by Vygotsky, have been studying the role of language as a determinant of human behaviour for over sixty years. Luria (1961) in outlining "the long path of development of the regulatory role of speech in the formation of the child's behaviour" (p.61), has also identified a stage at which it is the *meaning of what is spoken* rather than the *act of speaking* that begins to control behaviour. Behaviour analysts have finally taken up the challenge, and have recently begun the experimental analysis of verbal functions, and have proceeded with basic experimental work on the impact of verbal stimuli on human reactions to environmental contingencies.

In a chapter entitled "An operant analysis of problem solving" Skinner (1969) distinguished between two fundamentally different types of behaviour:

> "We refer to contingency-shaped behavior alone when we say that an organism behaves in a given way with a given probability because the *behavior has been followed by a given kind of consequence in the past.* We refer to behavior under the control of prior contingency-specifying stimuli when we say that an organism behaves in a given way because *it expects a similar consequence to follow in the future.* The 'expectancy' is a gratuitous and dangerous assumption if nothing more than a history of reinforcement has been observed. Any actual formulation of the relation between a response and its consequences (perhaps simply the observation, 'Whenever I respond in this way such and such an event follows') may, of course, function as a prior controlling stimulus. (Skinner, 1969, p.147).

Skinner's distinction between rule-governed and contingency-governed behaviour has been a spur to much of the recent behaviour analytic research on human behaviour. Vaughan (1989) concludes that it was "a distinction that not only breathed new life into the field, it unequivocally linked behavior analytic research and cognitive processes" (p.98).

The same research on human operant behaviour (e.g. Bentall & Lowe, 1987; Lowe, Beasty & Bentall, 1983; Lowe, Harzem & Bagshaw 1978; Lowe & Horne, 1985), that threw into doubt the utility of animal models of human operant behaviour, may also have helped set the foundations for a revitalized behaviour analysis. The "language hypothesis" (Lowe, 1979), derived from a marriage of Soviet and behaviour analytic research, has served to increase interest in operant psychology, and to focus attention on rule-governed behaviour.

1.3. RULE-GOVERNED BEHAVIOUR

Skinner's theoretical treatment of rule-governed behaviour evolved for a period of over forty years, but only for the last ten to fifteen years have behaviour analysts begun talking about it technically and studying it directly (Vaughan, 1989). Hayne Reese (1989), for example, posits two kinds of rules, 'normal rules' and 'normative rules'. The important distinction that he makes is between rules that describe the status quo, and those that influence it.

> "A normal rule is not causal; it can be instantiated, but it does not cause the instantiation. For example, the law of falling bodies as a regularity can be distinguished from the formula $s = {}^1/_2\, gt^2$, which is not the law but only a description of the law. The law as such does not cause bodies to fall; mutual attraction is the cause. A normative rule is causal if it controls behaviour (in conjunction with other variables)." (Reese, 1989, p.73).

Science is based on the assumption that all events in nature are lawful and that the laws of nature can be described by normal rules. It is the endeavour of scientists to formulate the normal rules that best describe the regularities that they observe. These descriptions do not alter what is observed. In all nature it is only the behaviour of verbally competent humans that can be altered or guided by the statement of a verbal rule (normal or otherwise). When this occurs, the rule is said to be normative, and it is this kind of rule that is of interest to behaviour analysts. The term 'rule-governance' does not refer to "general strategies of performance that can be stated in rule form. Rather, it is behavior that is directly impacted by verbal formulae." (Hayes, 1989). According to Catania (1992) rule-governed behaviour is:

> " .... behaviour, either verbal or nonverbal, under the control of verbal antecedents. In some usages, any verbal antecedent qualifies as a rule (as when one is told to do or say something). In others, rules are only those verbal antecedents that specify contingencies (as when one is told what will happen if one does or says something); such rules may alter the function of other stimuli. Some rules are self-produced; the most effective verbal antecedents are those that one generates oneself. Whether rule-following occurs in the presence of a rule is often ambiguous (one may repeat a rule to oneself at the time of following it); for that reason, rules do not necessarily qualify as discriminative stimuli even though they function as verbal antecedents." (Catania, 1992, p.393).

As Catania points out a rule can be verbally self-generated (shaped) or it can be imposed (instructed). In either case a rule may or may not impact upon a person's behaviour. A major challenge for behavior analysis is to provide a theoretical and empirical account of how and why rules are followed. Zettle and Hayes (1982) have postulated three categories of rule following distinguished by the type of contingency that motivates action with regard to the rule. The most fundamental of these they called 'pliance':

> "Pliance is rule-governed behavior under the control of apparent socially mediated consequences for a correspondence between the rule and

relevant behaviour. Thus pliance involves consequences for rule-following *per se* mediated by the verbal community. When a rule functions this way, it is said to function as a ply." (Hayes, Zettle & Rosenfarb, 1989, p.203).

In other words 'pliance', derived from the word *compliance,* involves consequences for rule following that are 'contrived'. For example, if when a mother says to her son "please wash the dishes, and then I will iron your shirt", he does wash the dishes, and this behaviour is under the control of the apparent consequences from his mother, then this is pliance. Even if the son does not wash the dishes, this could still be an instance of pliance ('counterpliance') if the cause of non-compliance was the perceived consequences from his mother (e.g. he did not want his shirt ironed). If the son refused to wash the dishes simply because washing up was too aversive, then this would not be pliance (or counterpliance). It should be noted a ply is defined only by its function, and that we cannot tell from the structure of either the mother's verbalization, or the son's behaviour, whether or not rule following is pliance. This can only be determined by manipulating the consequences of the son's behaviour.

"Tracking is rule-governed behavior under the control of the apparent correspondence between the rule and the way the world is arranged. A rule functioning this way is a termed a *track."* (Hayes, Zettle & Rosenfarb, 1989, p.206).

The second type of rule following has become known as 'tracking', which involves consequences for rule following that are 'natural' (not 'socially mediated' or 'contrived'). The distinction between natural and socially mediated consequences for rule following is not the same as the distinction between non-social and social consequences. Rule following of any kind must involve social variables (if only the rule itself), but social consequences *may* be natural. For example, if a well known comedian says to a man in the audience "tell this joke to your friends at home, because it is bound to make them laugh", and the man does tell the joke to his friends, and this behaviour is under the control of the apparent natural consequences (his friends' laughter rather than praise from the comedian), this would be an example of tracking. The rewarding consequences are social but natural (the laughter of the man's friends). As was the case with pliance, a track is defined only by its function not by its structure. (For a more detailed discussion of pliance and tracking, and the evidence for the distinction between them, see Hayes, Zettle & Rosenfarb, 1989, pp.202-215).

> "Augmenting is rule-governed behaviour under the control of apparent changes in the capacity of events to function as reinforcers or punishers." (Hayes, Zettle & Rosenfarb, 1989, p.206).

The third type of rule following is called 'augmenting', to suggest a changed or heightened state of affairs. An augmental is a verbal stimulus that alters the reinforcing/punishing status of another stimulus, or group of stimuli. The functioning of augmentals is more complex than that of plys or tracks, and according to Hayes *et al* (1989) augmenting rarely exists in its pure form, but is more likely to be mixed with pliance or tracking.

These authors propose that media advertising is often based on this kind of rule following, and the example they use to illustrate augmenting is a Burger King advert. They suggest that the advertising slogan "Aren't you hungry for a Burger King now?" could act as an augmental if when it is heard, it establishes the consequences of eating burgers as more valued. Hayes *et al* are not clear about the mechanisms that account for augmenting, but tentatively propose a process involving classical conditioning and stimulus equivalence, the details of which will not be discussed here. (For a fuller explanation, see Hayes, Zettle & Rosenfarb, 1989, pp.206-208).

It is important to note that the terms pliance, tracking, and augmenting refer to listener behaviours (rule following), and particular instances of these behaviours cannot be identified with reference only to a speaker's verbalizations. Speakers' verbalizations may at times not even function as verbal stimuli for a given listener. Conversely, it is important to note that, for a verbally able human, any stimulus (not just an overt verbalization) can act as a source of verbal stimulation in a given instance. For example, on a sunny afternoon a boy's mother tells him that she is going to dish out his favourite meal at seven o'clock. Much later, whilst out playing with his friends hears the town clock strike seven and he rushes home. The clock striking seven is obviously not a speaker's verbal behaviour, but the boy's actions cannot be understood except in terms of rule-governed behaviour. Thus, "Turning types of rules into *stimulus objects,* rather than contextually limited stimulus *functions,* eliminates most of the value of a behavioral perspective on rule-following."

(Hayes *et al*, 1989, p.208). In general, however, rules are produced by speakers, and speakers only speak because of the effect this has on listeners: without speech their would be no normative rules to follow.

Why did the first speaker speak, and why did this influence the behaviour of others? Clearly, the primary function of language is to instruct, to change behaviour, to give orders or advice, rather than simply to convey truth or reason. Cerutti (1989), like the rest of us, can only speculate about the phylogenic development of rule-governance:

> "It is likely that its origins lay in situations where stimuli provided by one individual were correlated with contingencies that affected the behavior of other individuals in important ways. The consequences of such interactions must have promoted the well-being of both speakers and listeners. In time as the repertoire grew, individuals could instruct one another on the basis of reliable personal experiences, and instructions could supplant learning through direct exposure to natural contingencies." (Cerutti, 1989, p.273).

The ontogenic development of rule-governance, on the other hand, can be studied experimentally and now behaviour analysts have joined the Soviet psychologists in the search for the underlying principles of rule-governance (or verbal regulation). Hayes, Thompson & Hayes (1989) suggest that:

> "rule following involves acting with respect to verbal stimulation at one point in time and, at a later point, acting in some other way with respect

to other stimulus conditions. Further, for the second interaction to constitute an instance of rule following, the first and second interactions must be related in some way. Skinner (1969, pp.146-152) has suggested a relation of 'specification'. More precisely, rule following implies functional substitutabilities among the stimuli constituting the rule and those constituting the conditions under which rule following is to take place (Hayes & Hayes, 1989; Parrott, 1987)...... How rules and the conditions they specify come to be functionally substitutable has not been addressed adequately in the rule-governance literature. Research has focused on the conditions under which rule following occurs, assuming that subjects already know what the rules refer to (e.g. Catania, Matthews & Shimoff, 1982; Galizio, 1979; S.C. Hayes, Brownstein, Haas & Greenway, 1986; S.C. Hayes, Brownstein, Zettle, Rosenfarb & Korn, 1986; LeFrancois, Chase & Joyce, 1988). It is not yet known how subjects know what rules refer to, nor how they can identify prevailing conditions as those specified or not specified in previously encountered rules." (Hayes, Thompson & Hayes, 1989, p.275).

It is clear that a verbal rule is a combination of words (verbal stimuli) that stand for or symbolize other stimuli. Behaviour analysts have begun not only to document the involvement of verbal stimuli in complex human behaviour, and to explain why verbal events affect human behaviour in certain circumstances, but also they are identifying functional processes that may provide a functional definition of verbal stimuli. There has been a recent surge of interest in the experimental analysis of the 'stimulus equivalence phenomenon', because of the apparent correspondence with language phenomena (Hayes & Hayes, 1992).

> "The emergence of equivalence from conditionality permits Behaviour Analysis to account for the establishment at least of simple semantic correspondences without having to postulate a direct reinforcement history for every instance. Instead of appealing to cognitions, representations, and stored correspondences to explain the initial occurrence of appropriate new behaviour, one can find a complete explanation in the (equivalences) that are the pre-requisites for the emergent behaviour (Sidman, 1986, p.236).

Sidman (1986) suggests that when a symbol and a printed word become equivalent then we may say that they have the same meaning or that each is the meaning of the other. He views the equivalence task as providing an operational definition for semantic correspondence.

> "The equivalence paradigm provides exactly the test that is needed to determine whether or not a particular conditional discrimination involves semantic relations." (Sidman & Tailby, 1982, p.20).

In very general terms, stimulus equivalence research involves teaching subjects to match comparison stimuli to sample stimuli. The stimuli are said to be equivalent if three relations between these stimuli can be shown: reflexivity, symmetry, and transitivity (Sidman & Tailby, 1982). For a relation to be reflexive, each stimulus must be matched to itself, for example, if "A" is the sample stimulus, then the subject matches it to the comparison stimulus "A". For a relation to be symmetrical, if stimulus "A" is matched to stimulus "B", then stimulus "B" must be matched to stimulus "A" (A=B). Finally, for the relation to be transitive, a subject is taught to match "A" to "B", and then "B" to "C", and then as a result, without further training, the subject matches "A" to "C".

Despite concerted efforts by many researchers, there has been no unequivocal demonstration of stimulus equivalence with non-human subjects, not even 'language trained' apes (see Dugdale & Lowe, 1990, pp.119-123). Indeed, the stimulus equivalence literature provides further evidence for a fundamental difference between human and animal behaviour. Dugdale and Lowe (1990) suggest that animals cannot pass equivalence tests because they have no verbal skills. Research with human subjects does indeed suggest that there is a relationship between language and equivalence (see Devany, Hayes & Nelson, 1986; Hayes & Hayes, 1992; Stoddart & McIlvane, 1986).

A series of studies conducted at Bangor indicate that, as many psychologists have suggested in the past, "physically different stimuli cannot become equivalent unless the subject names them" (Beasty & Lowe, 1985; Dugdale & Lowe, 1990; Hird & Lowe, 1985; Lowe, 1986; Lowe & Beasty, 1987). The results of these studies provided evidence that subjects, who could not name stimuli in ways that corresponded to the experimenter's stimulus categorizations, failed the tests of equivalence, and that whenever 'naming' was introduced equivalence emerged (Dugdale & Lowe, 1990; Lowe & Beasty, 1987).

Dugdale and Lowe (1990) define 'naming' in terms of a symmetrical relation between an arbitrary response and its controlling stimulus (stimulus response symmetry), and suggest that:

> "naming is necessary not just for equivalence but for forming a bi-directional or symmetrical relation between two visual stimuli. At the same time it has been argued that naming is itself a kind of symmetrical relation. The apparent circularity of this argument disappears when one draws a distinction between two kinds of symmetry, *stimulus-response symmetry* (naming) and *stimulus-stimulus symmetry,* the former being primary, and necessary for the emergence of stimulus-stimulus symmetry. This, of course, in turn raises the question of where stimulus-response symmetry comes from. One possibility is that stimulus-response symmetry emerges in the course of the training that occurs naturally within the developing child's linguistic environment (Dugdale & Lowe, 1987). During the early stages of language learning the child is taught language production and comprehension, that is, to function both as a speaker and as a listener. More specifically, the child is taught to say a particular word (or produce a particular sign) conditional upon a stimulus (the referent) and to do the reverse i.e. select that stimulus conditional upon the spoken word (or sign). The child receives an extraordinarily extensive history of reinforcement for responding correctly to innumerable exemplars of such stimulus-response symmetry. Perhaps then the naming relation emerges in childhood as one is repeatedly exposed by the verbal community to conditions in which stimulus-response reversals are reinforced." (Dugdale & Lowe, 1990).

This hypothesis is entirely consonant with Vygotsky's conception of language development and his account of the development of word meaning. One of Vygotsky's major concerns when considering the influence of speech on human behaviour was how the use of words leads to a "generalized reflection of reality" (1978, p.47). Vygotsky stressed that categorization or generalized word meaning is inextricably tied to human social interaction, and provides an important key to the understanding of human consciousness. He argued that the analysis of the development of word meaning must be carried out in connection with the analysis of the development of the function of the word in communication.

> "It may be appropriate to view word meaning not only as *a unity of thinking and speech,* but as *a unity of generalization and social interaction, a unity of thinking and communication.*" (Vygotsky, 1987, p.49)

Vygotsky makes an important distinction between reference and meaning, noting that although a young child and an adult may agree on the object designated by a word, their understanding of the word must be quite different. Numerous experiments conducted by Vygotsky and his colleagues have shown that from an early age a child learns that particular words (utterances) indicate particular objects - *the child learns a unidirectional relation between the word and the object,* but that the child's use of words soon develops beyond the function of indicating objects, i.e. the meaning of the word develops. Initially the child's understanding is diffuse, but through continued social interaction more precise bi-directional word-object correlations eventually develop - *the child learns the precise symmetrical relation between word and object in different contexts.* Later, through continued exposure to the word used in communication with others, "the word introduces the object into a system of connections and relationships, analysing and generalizing it" (Luria, 1987, p.364). The child begins to isolate the object's basic feature, subordinating this feature to a category - *the child learns a range of symmetrical and transitive relations between words and objects, or groups of objects (see Fields, Reeve, Adams & Verhave, 1991).* Finally during school age, the classification process changes fundamentally, and the child begins to create hypothetical categories with verbal definitions. At this stage the child learns word meaning not through direct experience with things, but rather through other words - *the child learns equivalence relations between words and other words without the need for direct experience with objects.* "As it is used in these communicative contexts, then, the word begins to function not only as a means of communication but as the object of communicative activity, with the child's attention being directed explicitly toward word meanings and their interrelationships" (Minick, 1987, p.27).

Soviet psychologists have charted the natural development of speech as a determinant of a child's behaviour. Behaviour analysts have shown how adult human behaviour is determined not only by contingencies, but also by the rules that humans formulate to describe those contingencies. By taking stock of the findings from both Soviet and basic behaviour analytic sources researchers are beginning to gain a clearer understanding of how people learn the meanings of rules, and why they follow them. A more complete account of complex human behaviour is beginning to emerge, and there is renewed hope, within behaviour analysis, that the new developments may indeed produce the 'powerful technology of behaviour change' that has been hailed for more than seven decades.

1.4. BEHAVIOUR CHANGE STRATEGIES

According to Krasner and Ullmann (1965, p.1), "The principles and technology of behavior modification were first developed and validated in a laboratory setting and then applied to the clinical situation." In 1975, Stoltz, Wienkowski and Brown defined behaviour modification as "a special form of behaviour influence that involves primarily the application of research in experimental psychology to alleviate suffering and enhance human functioning" (p.1027). Behaviour modification originated out of the study of animal behaviour in controlled experimental settings, and is the application of learning theory to the problem of how to effect socially useful changes in individual behaviour. However, because behaviour modification techniques based on principles derived from the animal research have proved unsuccessful in a number of areas, many applied psychologists have abandoned this approach (Lowe & Higson, 1983). Recently, behaviour change strategies arising out of developments in cognitive psychology have gained favour, and the term 'behaviour modification' no longer encompasses all behaviour change strategies that are derived from research in experimental psychology.

An approach, known as 'cognitive behaviour modification', has become widely adopted within applied psychology. The main aim of this approach is said to be the promotion of change in overt motor behaviour by influence on covert mediating variables (see Mahoney, 1974; Meichenbaum, 1977). The most widely practised technique of cognitive behaviour modification is a self-instructional training procedure developed by Donald Meichenbaum. Originally trained in operant psychology, Meichenbaum has become increasingly attracted to a cognitive approach (see Meichenbaum, 1977, 1990; Meichenbaum & Goodman, 1969). Influenced by Vygotsky's theory and the experiments reported by Luria, he developed a self-instructional training procedure to teach hyperactive and impulsive children to control their own behaviour. As a result of this application Meichenbaum developed a protocol consisting of the following steps:

1. An adult model (the experimenter) performs the task while talking to himself out loud. *(Cognitive modelling).*
2. The child (subject) performs the same task under the direction of the 'model's instructions. *(Overt, external guidance).*
3. The child (subject) performs the task while instructing himself aloud. *(Overt self-guidance).*
4. The child (subject) whispers the instructions to himself as he proceeds through the task. *(Faded, overt self-guidance).*
5. The child (subject) performs the task while guiding his performance via private speech. *(Covert self-instruction).* (Meichenbaum, 1977).

This training procedure in many ways recapitulates the stages that Vygotsky theorized to occur naturally within a social context as children develop self-regulatory speech (Whitman, 1987). Adults (clinicians/educators) initially provide considerable and specific assistance to guide the children's (client's/pupil's) behaviour, but gradually control is ceded and the children (clients/pupils) are encouraged to regulate their own behaviour with assistance given only as needed. Finally, the children (clients/pupils) assume complete regulatory control over their own behaviour.

Self-instructional training, and variants such as metacognitive training, have been shown to be relatively effective with a number of behaviours and populations in both clinical and educational settings. Successful applications have been reported with subjects exhibiting schizophrenic disorders (Bentall, Higson & Lowe, 1987; Meichenbaum & Cameron, 1973), hyperactivity (Douglas, Parry, Marton & Garson, 1976), impulsivity, aggression (Meichenbaum, 1977), anxiety, fear and depression (Dush, Hirt & Schroeder, 1983). These techniques have been used to improve children's classroom behaviour (Bornstein & Quevillion, 1976), and academic skills (see Pressley & Levin, 1983; Roberts, Nelson & Olson, 1987). They have also been applied in smoking cessation programmes (Nikki, Remington & MacDonald, 1984).

Despite its popularity and apparent success, cognitive behaviour modification currently has no firm conceptual foundation. Of the various conceptual frameworks within which cognitive behaviour modification may be viewed, social learning theory (Bandura, 1977), with its emphasis on reciprocal determinism and the causal properties of cognitions, appears to enjoy the highest status amongst practitioners of cognitive behaviour modification (Zettle & Hayes, 1982). This theory, which provides a framework for a number of cognitively oriented behaviour change strategies, was first put forward by Albert Bandura, who, like Meichenbaum, has become increasingly attracted to a cognitive approach (see Bandura, 1977, 1986; and Bandura & Walters, 1963). This shift in orientation is exemplified by the fact that in 1977 Bandura published a book setting out what he then called 'social learning theory', but in 1986 he revised his terminology and proposed the title 'social cognitive theory'. Like all cognitivists, Bandura interpolates between the occurrence of environmental antecedent events and overt behaviours cognitions which mediate the overt behaviours. Bandura invokes three mechanisms that underlie cognitively based motivation, goal-setting, self-evaluative reactions, and self-efficacy judgements (Karoly, 1993).

Bandura's theory has probably been preferred to the behaviour analytic account of the effects of cognitive behaviour modification because of the widely held false belief that behaviour analysis does not encompass private behaviour (Biglan, 1987). The radical behavioural perspective on cognitive behaviour has been so ignored and misunderstood partly because of the behaviour of many applied behaviour analysts. Remington (1991) concludes that criticisms of applied behaviour analysis usually "bear on one neglected dimension of ABA - the *conceptual system* within which it evolved. The distinctive glitter of Skinnerian conceptual analysis has gradually been obscured by a patina of technologically based interventions" (p.8). For methodological reasons, applied behaviour analysts have often considered only publicly observable behaviour as scientifically admissible. "Private events are thus relegated to a land of the hypothetical; never directly accessible and never, somehow, on a par with publicly observable organismic activity" (Zettle & Hayes, 1982). However, radical behaviourism, as espoused by Skinner and recently developed by a number of other researchers (such as Catania, Hayes, Lowe and many more), does not represent the rejection of cognitive events, but actually distinguishes itself from methodological behaviourism (as a philosophical position) by virtue of the fact that it "explicitly recognises that verbal behaviour, both overt and covert, functions as a determinant of other behaviour" (Lowe, 1983).

> "To the radical behaviorist, behaviour is regarded as observable organismic activity. Private events are regarded as stimuli or behavior that can be observed by an audience of one. [Public observability is not regarded as essential for scientific analysis (see Skinner, 1945).] Private events are given no special status simply because of the audience size. This does not mean that thoughts do not have special roles to play ...... but merely that privacy does not establish that status." (Zettle & Hayes, 1982, p.76).

The proposal of the "language hypothesis" (Lowe, 1979), the increase in human operant research, and the revived attention on rule-governed behaviour has led to the emergence of comprehensive behaviour-analytic explanations of (i) self-regulation and self-control, and (ii) the effects of supposedly 'cognitive' behaviour change strategies (see for example, Biglan, 1987; Lowe & Higson, 1981; Malott, 1989; Nelson & Hayes, 1981; O'Leary & Dubey, 1979; Poppen, 1989; Rosenbaum & Drabman, 1979; Zettle & Hayes, 1982; Whitman, 1990). The hope is that these re-interpretations will enable behaviour analysts to distinguish the functional components of cognitive therapies from those that are superfluous, thus paving the way for the development of even more effective behaviour change strategies. One of the behaviour change strategies that explicitly incorporates verbal control, and that has received considerable attention within applied domains in recent years, is 'correspondence training'. The literature on this approach will be considered in the next section of this chapter.

1.5. CORRESPONDENCE TRAINING

The relationship between an individual's verbal and non-verbal behaviours is central to developmental processes such as the regulatory function of speech, and learning to tell the truth (Israel, 1978).

> "As a child acquires the ability to use language to refer to things not present, it becomes possible for him to represent in words 'what might be' rather than simply 'what is'. As he does so his formulation may equally be a *fiction* - a make-believe - or a *plan*, and sometimes the two will be indistinguishable .... the ability either to sustain the make-believe or to carry out the planned activity is one that is developed as the facility in verbalizing grows." (Britton, 1971, p.12).

Vygotsky (1987) and Luria (1961) have shown that as children develop from a young age their behaviour is increasingly influenced by the language in their social environment. They soon become able to use that language to influence the behaviour of others, and at a later stage their language begins to affect their own behaviour. Eventually a child uses his own verbal behaviour to plan or predict certain behaviour sequences. A method that aims to encourage children (aged 3 years and older) to carry out their planned activities has become known as 'correspondence training'.

> "It is frequently assumed that what a person says he has done or will do relates to what he actually has done or will do. Much of psychotherapy .... is based on the assumption that reorganising and restructuring a

> patient's verbal statements about himself and his world will result in a corresponding reorganization of the patient's behavior with respect to that world. Similarly, education, in addition to teaching specific skills, strives to inculcate social attitudes - that is, verbal behaviors about the standards of society and the citizen's role in that society - which, it is hoped, will lead to behaviors that correspond to the verbalization of these attitudes. Since this assumption of a correspondence between verbal and non-verbal behavior is necessary for much of its affairs, society is concomitantly concerned with maintaining that correspondence. (Risley & Hart, 1968, p.267).

The correspondence training paradigm was developed from within the behaviour-analytic tradition, and was an extension of some previous work conducted in this field. For example, Brodsky (1967) had attempted to improve the social behaviour of an institutionalized learning disabled female by reinforcing her appropriate verbalizations concerning specific social behaviours. The subject's appropriate verbalizations increased, but there was no effect on her social behaviour. Similarly, studies by Lovaas (1961; 1964) and by Sherman (1964) had found only slight changes in a variety of nonverbal behaviours of pre-school children after conditioning of relevant verbal behaviour.

In the first volume of the *Journal of Applied Behavior Analysis,* before the current resurgence of interest in basic human operant research, Todd Risley and Betty Hart (1968) reported a study of 'correspondence training', a behaviour change strategy that makes use of the social consequences of verbal behaviour to control related nonverbal behaviour (Risley & Hart, 1968). Risley and Hart developed this training procedure to directly promote correspondence between subjects' overt verbalizations about their behaviour, and the performance of the behaviour referred to in these verbalizations. A great deal of applied behaviour-analytic research was stimulated by the publication of this work, because it was believed that, "If verbal - nonverbal correspondence were assured, a behavior change agent could control a subject's behavior, even in a remote and inaccessible setting, by prompting and reinforcing the subject's appropriate verbal responses (promises) about that behavior" (Baer, Williams, Osnes & Stokes, 1984, p.429). There are several variations of the basic method (see Paniagua, 1990), but the procedures always include differential reinforcement of matching verbal/nonverbal sequences. The generally stated aim of correspondence training is to promote generalized correspondence between 'doing' and 'saying about doing'.

> "To the extent that correspondence training encourages the individual to produce his or her own verbal cues and enhances the controlling function of such cues, it would seem to have potential for generalization to other situations. The individual can generate those cues in other than the original training situation. Maintenance of behavior change might also be enhanced by the individual producing the verbal cues in the absence of external cues for behavior." (Israel, 1978, p.271).

Two different training sequences have been employed with both young children and the learning disabled. In either procedure, prior to intervention, the behaviour of the subjects is observed in a target setting on several occasions during a baseline phase. The most common correspondence training sequence is a 'say - do' procedure (e.g. Baer, Detrich & Wenninger, 1988; Deacon & Konarski, 1987; Guevremont, Osnes & Stokes, 1986a, and 1986b; Israel & O'Leary, 1973; Ward & Stare, 1990; Williams & Stokes, 1983). After baseline, children (or learning disabled adults) are rewarded for saying that they will behave in a certain way, irrespective of whether or not they do behave as they said they would. This generally results in an increased frequency of 'saying', but not of 'doing'. During the next condition correspondence training is introduced, and rewards are given only if 'saying' and 'doing' correspond. The alternative correspondence training sequence is a 'do-say' procedure (e.g. Israel & O'Leary, 1973; Ribiero, 1989; Risley & Hart, 1968; Rogers-Warren & Baer, 1976). In studies employing this sequence subjects are first observed in a target setting, and are then asked to report on their behaviour in that setting. Initially, the subjects are rewarded for simply saying that they have been engaged in one particular target activity, irrespective of whether or not this is true. Generally, and not surprisingly, this does not result in increased participation in the target activity. In the next condition the contingency is altered so that the subjects are rewarded only when they both engage in the target behaviour, and report participation in that behaviour. Both correspondence training procedures invariably result in an increase in the rate of target verbal and nonverbal behaviours, and a 'do-say' procedure with children less than six years old has found that prompted 'saying' can control 'doing' up to 23 hours later (see Rogers-Warren & Baer, 1976).

The range of applications of correspondence training has extended to a wide variety of behaviours including sharing and praising (Rogers-Warren & Baer, 1976; Rogers-Warren, Warren & Baer, 1977), sitting posture and classroom behaviour (Whitman, Sciback, Butler, Richter & Johnson, 1982), food choice (Baer, Blount, Detrich & Stokes, 1987), rate and quality of written expression (Hopman & Glyn, 1989), choice of play-time activity (Baer, Detrich & Weninger, 1988; Williams & Stokes, 1983) and many more. These studies have clearly demonstrated that it is not enough to change what individuals say to themselves or others. It is necessary to ensure a correspondence between what people say and what they actually do. Correspondence training has been clearly shown to be an effective behaviour change strategy, but despite the expectations of its early researchers, two major problems remain. Although it is often possible to alter one specific behaviour in one specific setting, (i) these changes do not often generalize to other behaviours or other settings without further specific training, and (ii) the behaviour does not often persist over time after the removal of the behaviour change contingencies.

The correspondence training procedure was seen as useful to many researchers because of its perceived potential for developing generalized verbal control (i.e., the use of self-rules to control behaviours that have never been the target of training). However, very few studies have provided evidence for the development of generalized verbal control as a result of correspondence training (Deacon & Konarski, 1987). Risley (1977) suggested that to establish generalized correspondence one should train several specific correspondence relationships. Consistent with this view, Guevremont, Osnes & Stokes (1986a) utilized the correspondence training technique to train a consistency between a number of verbalizations and referent behaviours across increasingly remote settings and times. This study provided evidence that after a history of correspondence training across a number of behaviours in different settings, verbal control may generalize to other behaviours (and settings) in the absence of "salient externally imposed contingencies" (Guevremont, Osnes & Stokes, 1986a).

Studies that have evaluated maintenance in baseline conditions following correspondence training have found, that if the contingency is withdrawn abruptly, the target behaviour declines rapidly (e.g. Williams & Stokes, 1983). More recently researchers have begun to add reinforcement-based procedures to promote maintenance. Two studies have demonstrated a successful method of programming maintenance of correspondence using delayed reinforcement (Baer, Williams, Osnes & Stokes, 1984; Whitman, Sciback, Butler, Richter & Johnson, 1982). However, these procedures required the daily delivery of consequences throughout the maintenance condition. Thus, maintenance under extinction conditions was never measured. Later studies have provided evidence that making reinforcement intermittent, following intensive correspondence training, will sustain performance of the target behaviours, and improve maintenance in an extinction condition (Baer, Blount, Detrich & Stokes, 1987; Guevremont, Osnes & Stokes, 1986b). These researchers speculate that their procedures make the changes in the contingencies less discriminable to the subject (see Stokes & Baer, 1977; Stokes & Osnes, 1989). Evidence from other sources also suggests that gradual thinning of the schedule of consequence delivery is effective in promoting maintenance (e.g. Blount, Baer & Stokes, 1987; Kazdin & Polster, 1973).

Recently a number of studies have addressed two related issues concerning correspondence training. Firstly, researchers have questioned whether the results of correspondence training studies are best interpreted in terms of what they have called 'Luria's concept of verbal regulation', or in terms of rule-governed behaviour (e.g. Baer, Detrich & Weninger, 1988; Deacon & Konarski, 1987; Paniagua & Baer, 1988); secondly, they have attempted to determine the function of the 'subject verbalization' in the correspondence training procedure (e.g. Baer, Detrich & Weninger, 1988; Deacon & Konarski, 1987; Matthews, Shimoff & Catania, 1987; Ward & Stare, 1990).

Deacon and Konarski (1987) were the first to propose that "the notion of rule-governed behavior [rather than verbal regulation] can best account for the type of behavior changes seen in correspondence studies" (p.391). A firm grasp of the concepts of 'verbal regulation' and 'rule-governed behaviour' is required for an informed assessment of the validity of the Deacon and Konarski proposal. The concept of 'verbal regulation' as conceived by Soviet psychologists has been discussed in Section 1.2 of this thesis, and Section 1.3 has dealt extensively with the concept of 'rule-governed behaviour' as it has been developed within the behaviour-analytic tradition. Whilst the terminology used by

Soviet psychologists and behaviour analysts is different, it is quite apparent that both groups are concerned with language as a determinant of human behaviour.

According to Cerutti (1989), "the term *rule-governed behavior* is used to describe responding determined primarily by instructions." If this is correct (and see also Catania, 1992; Skinner, 1969; Vaughan, 1989; Zettle & Hayes, 1982), rule-governed behaviour is behaviour controlled by verbal constructs. Similarly, Luria views verbal regulation as the governing of behaviour by words and instructions. Whilst discussing the development of verbal regulation, he says:

> "the child, as he carries out an adult's verbal instruction, is subordinated to this word. The adult's word becomes a regulator of his behaviour ...... By subordinating himself to the adult's verbal orders the child acquires a system of these verbal instructions and gradually begins to utilize them for the regulation of his own behaviour...... In sum, speech, the basic means of communication, becomes also a means of deeper analysis and synthesis of reality and, more fundamentally important, 'a higher regulator of behaviour.'" (Luria, 1959, p.24).

Deacon and Konarski (1987) propose that, whilst Luria has stressed that the emergence of verbal regulation is a slow developmental process that involves many parent-child interactions, "it seems unlikely that verbal regulation can be developed within the time frame of most correspondence training studies' (p.398). It does not follow from this observation, however, that what is seen in correspondence training is not an example of verbal regulation. A second reason that Deacon and Konarski give for their proposal is that, "a key prediction based on verbal regulation is that it should lead to maintenance and generalization of behavior because it provides adequate verbal mediators" and, "Recent research has added reinforcement based generalization strategies to correspondence training because by itself, correspondence training has not been found to consistently produce generalized behavior changes" (p.398). What is said about correspondence training is true enough, but what Deacon and Konarski say about verbal regulation is appears to seriously misrepresent the Soviet position, since nowhere in the writings of Vygotsky or Luria is it suggested that an individual will *always* follow a particular verbal formulation irrespective of its consequences. In the present account, which has outlined in some detail both the verbal regulation theories of Soviet psychologists, and the behaviour analytic descriptions of rule-governed behaviour, there would appear to be no significant difference between the two notions; 'verbal regulation' and 'rule-governed behaviour' both refer to behaviour determined by verbal events.

Correspondence training has generally been applied to just one specific behaviour (e.g. playing with a specific toy or game). In other words, a child is taught to verbalize a specific self-rule (e.g. "Today I will only play with the lego"), and is rewarded for verbal - nonverbal correspondence. If there is a correspondence between the child's verbal and nonverbal behaviour, it could be argued that the child's behaviour is controlled by a 'discriminated correspondence rule' (Deacon & Konarski, 1987). A rule of this sort might take the form of a tact, such as, "To get the reward (a 'socially mediated' reinforcer) I must say that I will play with the lego, and then play with it." If such a rule is followed, this would be an instance of pliance, and as soon as the child learns that 'socially mediated' reinforcers are no longer being provided, then correspondence may cease. Indeed, most correspondence training applications have not produced impressive maintenance effects (see Baer, Blount, Detrich & Stokes, 1987; Baer, Williams, Osnes & Stokes, 1984, 1985; Guevremont, Osnes & Stokes, 1986b; Israel & O'Leary, 1973; Rogers-Warren & Baer, 1976), and this may be because the procedures have encouraged pliance, "rule-governed behavior primarily under the control of speaker-mediated consequences for a correspondence between the rule and relevant behavior" (Zettle & Hayes, 1982).

Risley (1977) suggested that to establish generalized correspondence one should train several specific correspondence relationships. Consistent with this view, Guevremont, Osnes & Stokes (1986a) utilized the correspondence training technique to train a consistency between a number of verbalizations and referent behaviours across increasingly remote settings and times. This study provided evidence that after a history of correspondence training across a number of behaviours in different settings, verbal control may generalize to other behaviours (and settings) in the absence of "salient externally imposed contingencies" (Guevremont, Osnes & Stokes, 1986a). In other words, it could be argued that a 'general correspondence rule' rather than a 'discriminated correspondence rule' was controlling behaviour (Deacon & Konarski, 1987). A possible general rule, developed as a result of these procedures, may have been the tact "If I do what I say, I will be given a treat (a "socially mediated" reinforcer)". If such a rule was followed, this again would be an instance of pliance. The results of the Guevremont *et al.* study (1986a) support this analysis, because it was noted that "the abrupt removal of contingencies rarely led to maintenance".

As mentioned earlier, the generally stated aim of correspondence training is to promote generalized correspondence between 'doing' and 'saying about doing'. As discussed in Section 1.3, a rule functioning as a track will maintain rule following in the absence of socially mediated contingencies. It may be that generalized correspondence will only develop when the child's behaviour is governed by a general (as opposed to 'discriminated') tact functioning as a track (for example, "When I do what I say, I will generally benefit", or "When I don't do what I say, everybody always tells me off"). For rule-governance of this kind to develop the 'real-life' benefits of following such a rule would have to be made apparent. In other words, as in the Guevremont *et al.* study (1986a), a number of instances of following the rule would have to be reinforced in a number of different contexts, but also, these behaviours would have to be rewarded in a number of different ways (or by a number of different people). The development of generalized correspondence tracking could be a slow process involving a great many interactions, and it may be that 'generalized correspondence tracking' develops in much the same way as has been described by Luria as the development of the highest form of 'self-regulatory speech'. In other words, generalized correspondence and verbal regulation may both refer to a tendency to control one's own behaviour with one's speech.

When, in the typical correspondence training paradigm, the contingencies controlling overt 'saying' are analysed separately from those controlling 'doing' (see Matthews, Shimoff & Catania, 1987), it becomes apparent that an overt verbalization by the subject may not be an important controlling variable (Baer, Detrich & Weninger, 1988). It was previously suggested that during correspondence training, the rule that controls behaviour is not equivalent to what is verbalized. For example, a child may say, "Today I will play with the lego", but the correspondence rule might be, "To get (the reward) I must say I will play with the lego, and then play with it." As pointed out by Paniagua and Baer (1982, 1988), correspondence training can be analysed as a chain of reinforced behaviours, and in that chain any behaviour could substitute the subject's overt verbalization. It is not even necessary that this behaviour is verbal. For example, if a child is told "To get (the reward) I want you to switch on the light then play with the lego", and the child follows the instruction, this would not be an instance of correspondence, but it would be pliance; switching on the light would stand in the same relation to playing with the lego as would an overt verbalization in correspondence training.

Although most researchers state that their aim is to promote generalized correspondence, their procedures may do nothing more than reinforce compliance (Wenninger & Baer, 1990). In most correspondence training research the experimenter selects the content of the subjects' verbalizations, and subjects are usually prompted to say that they will perform a low probability behaviour. The experimenter rewards subjects for saying what he instructs them to say, and for performing the behaviour specified in the instruction, but the said response class 'generalized correspondence' is not necessarily strengthened.

In three experiments that have compared the outcome of 'reinforcement of correspondence' with that of 'reinforcement of compliance', researchers have found no noteworthy difference in the response patterns of subjects in the two conditions (Baer, Detrich & Weninger, 1988; Deacon & Konarski, 1987; Weninger & Baer, 1990). Baer *et al.* (1988) conclude that "an antecedent verbalization regarding the target behavior is important, but it may not matter whether the child or the experimenter emits this verbalization." Deacon & Konarski (1987) surmise that, "whereas logic would dictate the necessity of some relevant verbal behavior by the subject to develop correspondence, apparently it need not be overt or necessarily prompted by the experimenter." In a fourth comparison study, however, Ward and Stare (1990) claim to have provided evidence that a correspondence training condition may promote better generalization of the correspondence effects to untrained behaviours than a 'compliance' condition. Clearly, as demonstrated by Baer *et al.* (1988), the effects of correspondence training procedures depend on verbal (instructional) control, but the importance of having the subject make overt verbalizations remains unclear, and further research is needed to resolve this issue.

A correspondence rule may be defined as one about 'saying' and 'doing', for example, "To get the (reward), I have to say and do (response)". A compliance rule, on the other hand, may simply require the following of an instruction, for example, "To get the (reward), I have to do what (the experimenter) says". It seems reasonable to suggest that the type of rule that is developed and followed by subjects in an experiment will depend to a large extent on the sequence of experimental procedures. In the comparison studies discussed above (Baer, Detrich & Weninger, 1988; Deacon & Konarski, 1987; Ward & Stare, 1990; Weninger & Baer, 1990) *all* of the subjects were first exposed to a 'reinforcement of verbalization' condition *before* either the correspondence or the compliance conditions. Some subjects, who were never exposed to the correspondence condition, but were later rewarded for 'saying' tended (in this condition) to behave as if they were following a correspondence rule (i.e. 'saying' and 'doing' corresponded). It may be that prior exposure to a 'reinforcement of verbalization' condition influenced the type of rule that governed the subjects' behaviour in later conditions, and that a study in which subjects are never rewarded for 'saying about doing' before a compliance condition would provide a better comparison to the effects of a correspondence training procedure.

When considering the utility of correspondence training in any given context one may ask whether there is any benefit in promoting the following of a correspondence rule rather than a compliance rule. Does correspondence training necessarily promote better maintenance effects and better generalization to other behaviours and settings? A study which compares the outcome of correspondence training and a compliance procedure in which subjects are never required to 'say about doing' would provide the best test of this possibility (Weninger & Baer, 1990).

The first two experiments in the current study were designed as a naturalistic investigation of the treatment and maintenance effects of a correspondence training programme (Experiment 1) and a compliance procedure (Experiment 2). In contrast to other studies that have compared procedures, subjects in Experiment 2 were never exposed to a reinforcement of verbalizations condition. The efficacy of the procedures was tested within the domain of dental health promotion, and the target was to promote improvements in the toothbrushing behaviour of six year old children.

CHAPTER 2.

CORRESPONDENCE TRAINING AND COMPLIANCE:
THE EFFECTIVENESS OF DIFFERENT INSTRUCTIONS CONCERNING TOOTHBRUSHING.

2.1. INTRODUCTION

Our permanent teeth begin to come through when we reach the age of five years old. Given the links between childhood dental hygiene, caries and adult gingivitis, it is critical that good toothbrushing habits are established at an early age. There is evidence to suggest, however, that children younger than five years old do not have the manual dexterity required to brush their teeth effectively (Levine, 1986). For these reasons, the subjects recruited for the current research were all between the age of five and six years old.

Children are usually given dental hygiene instruction at school. However, it has been demonstrated that such instruction programmes have little or no effect on the cleanliness of children's teeth (Silversin & Kornacki, 1984). This is not surprising given the findings of behaviour analytic research. Firstly, it has been shown repeatedly that instruction, and even self-instruction, in and of itself, will not produce behaviour change. It is necessary to reinforce a correspondence between the instruction and instruction following behaviour (Baer, Detrich, & Wenninger, 1988). Secondly, as pointed out by several researchers (e.g. Cerruti, 1989; Risley, 1977; Zettle & Hayes, 1982), instructions are most effective when they are given in the setting where the instructed behaviour is to take place. Targetting toothbrushing at home would circumvent many of the difficulties of generalization from one setting (school) to another (home), as well as generalization of brushing from school days to nonschool days

(Blount, Baer & Stokes, 1987). The behaviour change intervention is best administered by a member of the child's family, since rule following behaviour is more likely when the subject believes that the rule giver is able to verify the correspondence between the rule and behaviour (see for example, Zettle & Hayes, 1983).

Three behaviour change strategies were considered for the current research. For a number of reasons correspondence training (Risley & Hart, 1968) was considered more suitable than either self-instruction (Meichenbaum, 1977), or metacognitive training (Brown & Campione, 1984). Both of the latter methods, although useful for teaching new skills and modifying behaviour, require intensive interaction between the subject and the experimenter. Self-instructional training requires a complex series of steps involving modeling and verbal instruction. A trained experimenter must make several informed judgements about whether the subject has reached the level of achievement necessary for moving on to the next stage of the procedure (see Meichenbaum, 1977). Metacognitive training requires that the experimenter employs a 'Socratic dialogue' technique to question subjects about the target behaviour in such a way as to make them think more 'strategically' (Brown & Campione, 1984). Both procedures would be difficult to teach to the subjects' parents. The correspondence training procedure, on the other hand, is relatively simple to conduct, and a few studies have demonstrated that carers (without formal training in behaviour analysis) were able to learn it quickly and to apply it without great expenditure of time (see for example, Hopman & Glyn, 1989; Whitman, Sciback, Butler, Richter & Johnson, 1982).

Correspondence training is clearly an effective behaviour change strategy that promotes rule following, and it has been found to be particularly useful with children younger than the age of seven (e.g. Baer, Blount, Detrich & Stokes, 1987; Guevremont, Osnes & Stokes, 1986a, 1986b: Risley, 1977; Rogers-Warren & Baer, 1976). There are, however, relatively few documented applications of correspondence training to health-related behaviours. Notable exceptions are sitting posture (Whitman, Sciback, Butler, Richter & Johnson, 1982), and choice of healthy food snack (Baer, Blount, Detrich & Stokes, 1987). A study of the application of a correspondence training procedure to children's toothbrushing would be a valuable contribution since it would extend the range of socially useful behaviours to which this method has been applied.

The first two experiments in the current study were designed to address several issues concerning rule-governance in correspondence training and a related procedure. The purpose of first experiment was to determine whether a 'say-do' correspondence training procedure could be administered by parents in their own homes to effectively promote beneficial routine toothbrushing in young children. In this experiment 'saying' referred to two temporally separate instances of 'doing'. During the correspondence training phases 'saying about doing' was prompted 2-5 hours before the first instance of 'doing' (evening brushing), *and* 14-16 hours before the second instance of 'doing' (morning brushing). Consequences were delivered approximately 24 hours after the prompted 'saying about doing' (i.e. never after the first specified occasion for 'doing', and about 8 hours after the second specified occasion). Since children should ideally perform their toothbrushing behavior habitually without material rewards from parents, these were faded in the maintenance condition, and follow-up measures were taken two months later. The aim of second experiment was to examine whether a compliance procedure, in which the subjects were *never* required to overtly 'say about doing', would establish behaviour as effectively as correspondence training. This experiment was procedurally very similar to the first except that parental instructions about the contingencies replaced child verbalizations. The procedure was different to the those used by other researchers who have made similar comparisons, insofar as the children in this experiment were not exposed to a 'reinforcement of saying' condition before the compliance condition was introduced.

In order to maximize ecological validity and long-term maintenance of behaviour change, (i) all observations were conducted in the subjects' own homes; (ii) behaviour was recorded by video cameras; (iii) parents conducted all the interventions (as instructed by the experimenter, who did not come into direct contact with the subjects); (iv) experimenter-imposed contingencies were systematically faded out.

2.2. GENERAL METHOD

The general subject, apparatus, and procedure specifications apply to all 8 experiments unless exceptions are noted.

PARTICIPANTS

(a) Subjects

Twenty eight 5-6 year old normal children participated in eight experiments. These children were selected because they did not brush their teeth well without prompting or supervision, and they did not have an older sibling who was less than fourteen years old. A letter describing the aims of the study was sent to parents of children at local primary schools (both private and state funded). Parents who indicated an interest in hearing more about the experiments were contacted, and later interviewed at home without their children.

(b) Parents

The socioeconomic background of participating parents was not controlled, but this varied across the whole spectrum of British society from permanently unemployed single parents to very affluent two income families. All parents agreed to allow concealed surveillance of their child's toothbrushing behaviour in the family bathroom. One or both of the parents also agreed to administer all of the experimental interventions. The researcher gave all parents written instructions about the procedures at the beginning of each experimental phase. Care was taken to ensure that these instructions were understood and followed correctly. Target parent-child interactions were monitored on video, and feedback was given to parents regularly about their performance. Parents signed a written declaration of intent to follow all instructions to the best of their ability.

Figure 2.2.1

A photograph of the apparatus as seen from a subject's viewpoint when installed in the family bathroom.

Settings and Materials

The experiments were conducted in each child's family bathroom. A small hinged cabinet, faced with a 2-way mirror, was mounted on a wall near the wash basin at the child's head-height (see Figure 2.2.1). Concealed within each cabinet was a small CCD video camera and a microphone, and these were connected via hidden cables to a video cassette recorder (VCR) situated in another room. A toothbrush holder for only one toothbrush was fixed to one side of each mirror cabinet. Fitted to the bottom of the toothbrush holder was a microswitch that controlled the VCR, so that recordings were only taken when the toothbrush was removed. In order to facilitate data analysis the VCR's were set up to automatically mark the date and time on all recordings.

The parents of each subject were given a non-decorative calendar and adhesive paper stars (some gold, some silver, and some green) to enable them to implement the token reinforcement systems. The parents also chose items from a catalogue of inexpensive games, books and toys (approximate value = £2 or less) to be used as rewards for their children.

Dependent Variables and Recording

(a) **Target Behaviours**

Dependent variables in all experiments included: (i) the frequency of toothbrushing, which was simply a count of the number of separate occasions that a subject brushed his/her teeth per day; and (ii) the duration of each toothbrushing event.

For the purpose of data collection an experimental "day" always began at 3.00pm on one calendar day and ended at 3.00pm the following calendar day. Any toothbrushing event after 3.00pm was deemed to have occurred in the evening session and any event after midnight, but before 3.00pm, was deemed to have occurred in the morning session.

The duration of a toothbrushing event was defined as the total time (seconds) during which the bristles of the brush were in contact with, and moving against, the surfaces of teeth or gums. During the course of one brushing event a subject may start and stop brushing several times. It was decided that any toothbrushing event with a total duration of less than five seconds should be regarded as a non-occurrence with respect to frequency, and the duration was scored as zero. This decision was taken to exclude from the data analysis toothbrushing events that were of no clinical value.

(b) **Data Collection**

The primary source for data collection was the VCR which recorded the toothbrushing events and target verbalizations whenever the toothbrush was removed from the holder. Video recordings of the target interactions between parents and children were made to ensure that parents administered all instructions, feedback, and rewards correctly. The real time counter that was recorded on videotape with each brushing event was used to measure toothbrushing durations. The video cassettes in the VCR were exchanged frequently throughout the study so that recordings could be analysed regularly.

The parents of each child were given specially-prepared diaries in which to record the following information every evening and morning: (i) whether their child had brushed his/her teeth, (ii) the approximate time that this occurred, (iii) relevant verbal comments made by the children that were not recorded on video, and (iv) other events that may have affected the interpretation of results.

(c) **Reliability**

Frequency data from the video recordings and the parents' diaries were collated and compared. There were no occasions when parents' diary entries contradicted video recorded data. On the few occasions that the video equipment failed to function correctly records from the parents' diary entries were used to complete the frequency data, and no attempt was made to estimate the duration of brushing events that were not recorded on video.

A second observer independently measured toothbrushing durations from 20% of the video-recorded occurrences in each experiment. These were distributed evenly across subjects and experimental conditions, so that at least one in five of each subject's recordings in each condition was checked. The first observer was informed that the reliability of a random sample of observations would be assessed since this instruction tends to increase observer accuracy (Taplin & Reid, 1973). To avoid bias the second observer was uninformed about experimental procedures and conditions. Because subjects usually start and stop brushing several times during the course of a single brushing event, each estimate of the duration of an event requires that observers make several difficult discriminations. Exact agreement about the duration of an toothbrushing event (to the precise second), was therefore not the norm, and so the chosen methods of calculating agreement reflected the need only to assess covariation and approximate agreement in terms of absolute duration.

Agreement between observers was assessed using two different methods. Firstly, Pearson's Product-moment correlation coefficient was calculated to give a measure of the covariation of observer data across sessions.

i.e. **Pearson's r** $= \dfrac{\Sigma xy}{\sqrt{(\Sigma x^2)\ (\Sigma y^2)}}$

where $x = (X - \overline{X})$, $y = (Y - \overline{Y})$,

and X = each observer 1 value

$$\overline{X} = \frac{\text{total of all observer 1 values}}{\text{total number of observer 1 values}}$$

Y = each observer 2 value

$$\overline{Y} = \frac{\text{total of all observer 2 values}}{\text{total number of observer 2 values}}$$

This calculation gives values from zero (indicating a complete lack of relationship between scores) to one (for a perfect relationship). A plus or minus before the numerical value of the correlation coefficient indicates the direction of the relationship. Thus, a positive correlation would indicate that when one observer recorded a large value, the second observer tended to do so as well, and when one observer recorded a low value, so did the other one. A negative correlation would indicate that whenever the first observer recorded a high value, the second observer tended to record a low one, and viceversa. Pearson's Product-moment correlation gives a good indication of the extent to which observers' scores covary (tend to fluctuate in the same direction from occasion to occasion), but it tells us nothing about how close the observers' scores are to each other in absolute terms. Indeed, improbable though it may be, if one observer always scored a duration twenty (or any constant number) times more than the other observer for each session in which agreement was checked, the correlation would be perfect (r = +1.00).

The Frequency Ratio method provided the second measure of interobserver agreement. Each observer's duration estimates for the checked sessions of each subject in each phase were totalled. The smaller of these totals was then divided by the larger and multiplied by a hundred to give a percentage agreement.

i.e.

$$\textbf{Frequency Ratio} = \frac{\textbf{Small Value}}{\textbf{Large Value}} \times \textbf{100}$$

Despite its many faults, the Frequency Ratio method gives a good indication of the degree of absolute agreement between observers, particularly for measures (such as duration of toothbrushing) that can theoretically take on any value (Kazdin, 1982). When used together, Pearson's Product-moment correlation and the Frequency Ratio give an adequate account of agreement between observers for the current analysis.

EXPERIMENTAL DESIGN

In each of the eight experiments the effects of the interventions were evaluated in multiple-baseline across subjects designs (Kazdin, 1982). After baseline in each experiment the subjects were exposed to a predetermined sequence of different intervention conditions. Follow-up recordings of each subject's behaviour were taken eight weeks after the end of the last intervention condition.

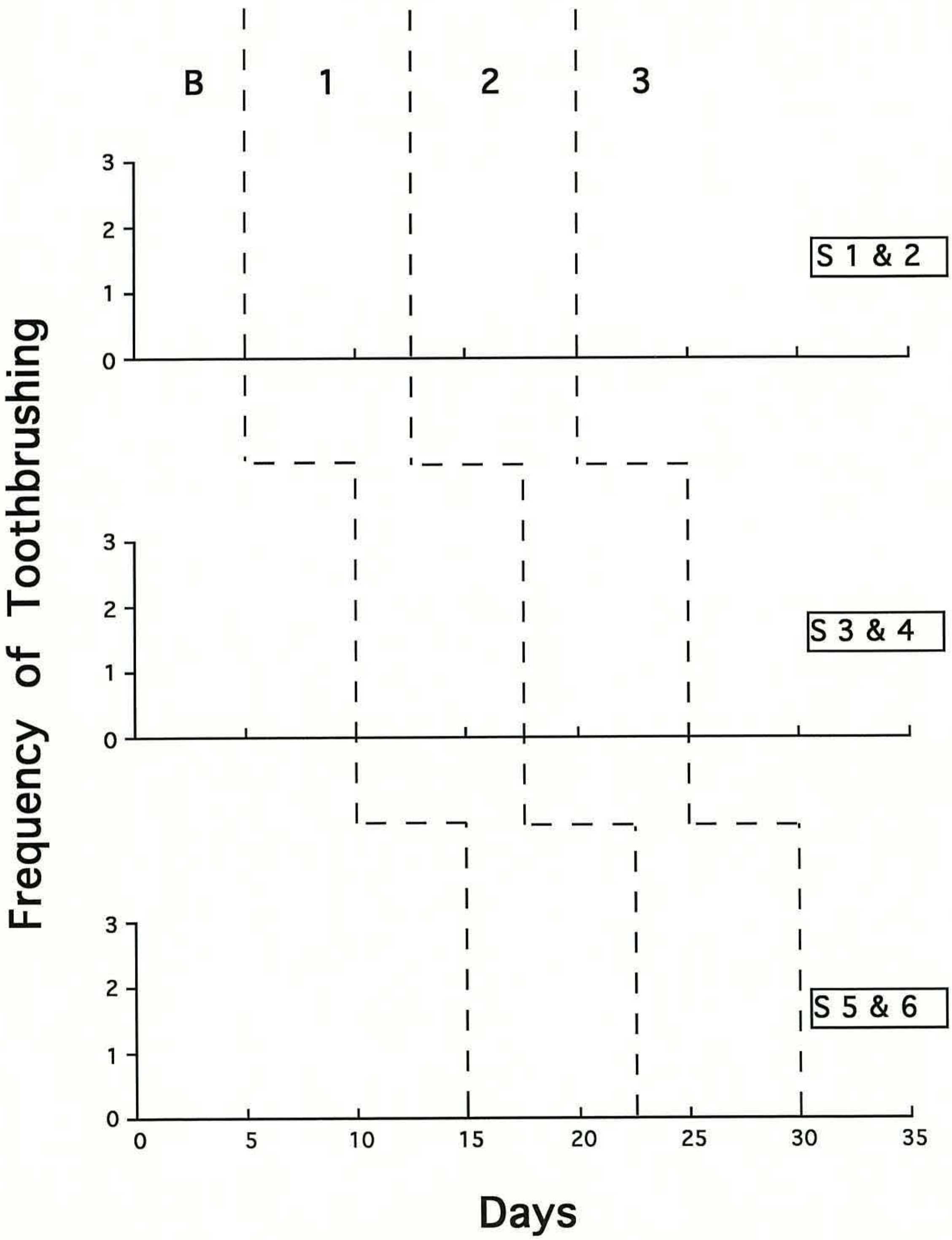
Between groups designs were not considered for this programme of research, because only six sets of the very expensive recording equipment were made available at the beginning of the project. For the following reasons, the multiple-baseline across subjects design was selected from among the several within-group, or single-subject designs, that are widely used in behaviour analytic research to demonstrate internal validity (experimental control). (1) In common with the other within group designs, it does not require a control group, and enables researchers to draw causal conclusions about efficacy of interventions without the need for great numbers of subjects in each experiment. (2) Repeated observations of performance over time is an integral part of the methodology, and allows a 'fine grained' analysis of how the interventions affect behaviour from day to day. For example, one can observe whether an intervention affects behaviour immediately on the first day, or more gradually over several days; one can also determine whether the effects are transient, or whether they are sustained over time. (3) The effectiveness of a number of different interventions can be evaluated within the same experiment, thus allowing more economical experimentation. (4) This design, unlike the ABAB design, does not require for the purpose of demonstrating experimental control, a return to Baseline levels of performance after an effective intervention. This is a major advantage, since it it would not be in the subject's interest to reverse or temporarily suspend a positive treatment effect.

Figure 2.2.2 is an illustrative example of how a multiple-baseline across subjects design can be employed for one measure (in this case frequency of toothbrushing per day). A comparison of repeated measures of behaviour is made throughout the Baseline (B) and Intervention conditions (1, 2, and 3). One can examine whether performance changes after the first intervention is introduced to the first group of subjects (S1&S2), and whether the other groups, not yet exposed to the intervention, continue at their Baseline levels. One can then examine whether the same effect occurs when the intervention is introduced with the second group (S3&S4), and then with the third group (S5&S6). If every time the treatment is introduced the same change occurs, then it

Figure 2.2.2

A prototypical example of the multiple baseline across subjects (S1 & 2, S3 & 4, S5 & 6) design employed for one measure (frequency) in the 8 experiments. The phases illustrated in this example are Baseline (B) and three intervention phases (1, 2, and 3).

Figure 2.2.2


B
1
2
3
S 1 & 2
S 3 & 4
S 5 & 6
Frequency of Toothbrushing
Days
0
1
2
3
0
5
10
15
20
25
30
35

can be safely concluded that this is due to the experimental manipulation. Similarly, if there are uniform changes in performance after the introduction of further interventions (2 and 3), then these changes can be attributed to the altered conditions.

PROCEDURE

The children were never made aware that their tooth-brushing behaviour was monitored on video, they never met the experimenter, and were led to believe that no-one other than their parents were involved in the procedures. The experimenter visited each household regularly throughout all experiments in order to (i) give instructions and materials to parents, (ii) exchange the video cassettes in order to examine the recordings, and (iii) check that the equipment was functioning as it should. Visits to households were usually made when the children were not at home in order to preclude contact between the children and the experimenter. When appropriate, and in order to maintain experimental control, parents were regularly given immediate feedback about their own behaviour as well as the subjects' target behaviours.

Prebaseline

The experimental equipment was installed in each household at least four days before Baseline measures were taken. During the Pre-baseline phase each parent determined that their child was able to perform all the constituent behaviours of toothbrushing. This time also served to allow the children to become accustomed to brushing their teeth in front of the mirror, and to minimize novelty effects in the following phases. The parents were able to use this phase to practise accurate administration of instructions in front of the camera.

On the first day of this phase, the parents of each child were given printed instructions asking them to show their child the new mirror and toothbrush holder at the first available opportunity, and to say:

> *"Look, we have a new mirror in the bathroom, and it has a special holder on it for your toothbrush. You can use the mirror to look at yourself when you brush your teeth or wash your face. Whenever you are not using your toothbrush, you should keep it in its holder so that it stays clean."*

After the evening meal parents escorted the subjects to the bathroom, removed the toothbrush from the holder to activate the VCR, and asked the children to perform the following actions:

(i) remove the top from the toothpaste tube,

(ii) apply the paste to the brush,

(iii) replace the toothpaste top,

(iv) turn on the tap,

(v) brush every part of every tooth and gum,

(vi) rinse the brush and mouth, and

(vii) turn off the tap.

Parents were allowed to assist if a child had difficulties, but were told to encourage their child to perform the actions independently. In all cases the children demonstrated that they could perform all the behaviours adequately without assistance within three days after the beginning of the prebaseline phase.

The notes accompanying parental instructions stressed that parents should avoid discussing toothbrushing with their children in any context other than that specified by the instructions. The target behaviours of the subjects and parents were monitored daily during this and every other phase.

Baseline

Interviews with parents of children aged five and six revealed that toothbrushing practices vary greatly. Some parents said that *they* normally brush their child's teeth; others said they liked to be present when the child brushed so that they could supervise; yet many others said that usually they simply tell their children to "go and brush their teeth".

Practices were standardized in Baseline. The printed formal instructions stated that on the first day, before the evening meal, the parent should take the subject into the bathroom, remove the toothbrush from the holder (to activate the VCR), and say to the child:

> *'From now on, because you are getting big, I won't be watching you brush your teeth. I won't be helping you and I won't remind you. You will have to remember to do it yourself. Okay?'*

Additional to the notes given in the Prebaseline phase, the notes for this phase stressed that parents should not prompt the children in any way to brush their teeth at any time. These conditions applied for all the intervention phases following Baseline in all of the experiments.

Interventions

Various different interventions were systematically introduced after Baseline in each experiment. In all cases an experimenter-defined reinforcement contingency was placed on some aspect of the subjects' toothbrushing-related behaviour, and the children were rewarded for following a particular set of instructions. The length of these conditions was either set in advance, or it was dependent on behavioural criteria such as stability of performance. Details of the particular interventions employed are given separately in the individual experimental method sections.

Maintenance

The last intervention phase in each experiment was a 'Maintenance' condition in which the experimenter-imposed reinforcement contingencies were faded out in a sytematic fashion. Material rewards were given intermittently contingent upon the subject brushing his/her teeth at or above a predetermined criterion level. These rewards were given less and less frequently so that initially a child would have to brush successfully for two days. After this the criterion number of days brushing was gradually increased. This procedure resembles the "Thinning" procedure reported by Blount, Baer and Stokes (1987).

Additionally, following from the suggestion to "introduce natural maintaining contingencies" (Stokes & Baer, 1977), parents were encouraged to replace the rewards supplied by the researcher with privileges and treats such as outings, and to continue to provide lavish praise for good brushing behaviour. They were asked to pair cuddles and other affectionate signs of approval with the generous verbal praise.

At the end of this phase, the VCRs were switched off, disconnected, and removed from the homes. The remainder of the apparatus was left in place so that the children would continue to use the mirror and toothbrush holder. No attempt was made to control the behaviours of parents or children during the time between the maintenance phase and the follow-ups.

Follow-up

The VCRs were reconnected for the Follow-up recordings eight weeks after the end of the Maintenance condition. Follow-up was always divided into two phases of equal duration (four days each in Experiments 1 and 2, nine days each in all subsequent experiments). Conditions in the first follow-up phase varied between experiments, but Baseline conditions always applied throughout the second Follow-up phase.

2.3. EXPERIMENT 1

The purpose of the first experiment was to determine whether a 'say-do' correspondence training procedure (Israel & O'Leary, 1973) could be administered by parents in their own homes to promote beneficial routine toothbrushing in young children. In this experiment the 'saying' referred to two temporally-separate instances of 'doing', thus providing a measure of 'near' and 'far' correspondence between verbal and non-verbal behaviour. During correspondence training interventions the children were prompted, before the evening meal, to make a verbalization of the intention to brush all teeth and gums once before bed time, **and** once the next morning after breakfast. Feedback and consequences were only delivered the following day before the evening meal (approximately 24 hours after the subjects' prompted verbalizations, never after the first specified occasion for toothbrushing, and about 8 hours after the second specified occasion).

METHOD

PARTICIPANTS

(a) **Subjects**

Five children took part, three girls (Sally, Helen and Susan) and two boys (Simon and Frank)*. Their mean age was five years nine months (see Table 2.3.1 for complete subject and sibling details). Although all were considered developmentally normal with no major behaviour problems, Susan's toothbrushing habits were a source of conflict in her family.

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* Note: These are all fictitious names.

TABLE 2.3.1

AGE OF SUBJECTS AND THEIR SIBLINGS

EXPERIMENT 1

Subject	Age at start	Number of Siblings	Age of Siblings
Sally	5 yrs 7 mths	0	-
Helen	5 yrs 7 mths	0	-
Simon	5 yrs 7 mths	1	14 yrs
Frank	5 yrs 11 mths	0	-
Susan	6 yrs 3 mths	0	-

Mean age of subjects at start = 5 yrs 9 mths

(b) **Parents**

In four families the subject's mother administered all of the interventions. In Sally's family this role was shared by both parents.

Dependent Variables and Recording

(a) **Target Behaviours**

The dependent variables in this experiment were: (i) toothbrushing frequency, (ii) toothbrushing duration (see General Method section for details), and (iii) overt verbalizations of a target statement by the subjects (see Procedure section for details).

(b) **Reliability**

There were no occasions of disagreement between the experimenter and the parents about subjects' verbalizations of the target statement, or toothbrushing frequency. Pearson Product-moment correlations between the toothbrushing duration observations of the two scorers were always close to +1.00, indicating reliable covariation. The overall correlation between the scorers' observations was 0.971, and for individual subjects the correlations were: Sally, 0.974; Helen, 0.990; Simon, 0.936; Frank, 0.972; and Susan, 0.985. Computations of Frequency Ratio's were close to 100% in all cases, indicating a high degree of absolute agreement between observers' estimates of duration. Percentage agreement was: overall, 96.9%; Sally, 99.8%; Helen, 99.6%; Simon, 90.0%; Frank, 99.3%; and Susan, 95.7%. Reliability was calculated using both methods for each of the subjects in each experimental condition, and was found to be very similar across phases for any one subject. For this reason, in this and all subsequent experiments, only the overall reliability scores are reported.

Experimental Design

Baselines in this experiment were four days (Sally), seven days (Helen and Simon), and ten days (Frank and Susan). After baseline all of the subjects were exposed to the following sequence of four different intervention conditions:

(1) Subject Verbalization

(2) Frequency Correspondence Training

(3) Duration and Frequency Correspondence Training

(4) Maintenance of Correspondence.

Procedure

Subject Verbalization

On the first day of this phase parents were given the non-decorative calendar, some adhesive gold stars, and seven presents that they had selected for their children from the catalogue.

The printed instructions stated that on the first afternoon, before the evening meal, parents should tell their child (in the bathroom with the toothbrush removed) that to keep teeth and gums healthy and clean they should remember to brush teeth twice each day, once at night before going to bed, and once in the morning after breakfast. Following this, and at this time on every other afternoon during the phase, parents asked the question, *"What are you going to do to keep your teeth healthy and clean?"'* Contingent upon the child making the response, *"Every night and every morning, I will brush every part of all of my teeth and* *gums"*, parents immediately praised the child, placed a gold star on the calendar, and presented a material reward. This intervention phase lasted for seven days, and parents were allowed to assist the child to verbalize the statement accurately on the first three.

Frequency Correspondence Training

Parents were now given more of the toys they had chosen from the catalogue, and some green adhesive stars. In this phase the instructions to the child indicated that rewards were to be made contingent on saying the target statement, *and* actually brushing teeth every night and every morning. On the first day, after the child had said the target statement, the parent gave verbal praise, a gold star and a present. The parent then said:

> *'But, let me look at your teeth.* [The parent looked into the child's mouth.] *I don't think that you have been brushing your teeth* ***every*** *night* ***and every*** *morning. You say that you will brush your teeth every night and every morning, so tomorrow evening, I will only give you a gold star and a present if you do what you say. If you only remember to brush your teeth once I will give you a green star, but no present. Okay?'*

The following afternoon, before the evening meal, children who had brushed their teeth twice were given a gold star and a present. Those who brushed only once were told the occasion on which brushing had been forgotten, and were given a green star but no present. Those who did not brush at all were told that because they hadn't brushed their teeth they could not have a star or a present, but were encouraged to try harder next time. In all cases the parents then asked, *'What are you going to do to keep your teeth healthy and clean?'* After the child had replied with the target statement, the parent restated that a gold star and a present would only be given the following evening if the promise was fulfilled. This same procedure was used everyday for the rest of the phase (at least seven days).

Duration and Frequency Correspondence Training

This intervention was introduced only when a child brushed twice each day for at least three consecutive days. Parents were given silver adhesive stars and more toys selected from the catalogue. Rewards were now delivered dependent not only on the child saying the statement and brushing twice each day, but also on the child brushing for longer than a predetermined minimum duration on each occasion. A different criterion based on previous performance was adopted for each child, and this was adjusted by the investigator in order to shape up increasing duration of toothbrushing both in the evening and in the morning.

On the first afternoon of this phase, after the child had been given feedback and rewards for brushing twice on the previous day, the parent looked again at the child's teeth and said:

> *'Remember that you say "I will brush **every** part of **all** of my teeth and gums". Tomorrow evening I will only give you a gold star and a present if you do brush **every** part of **all** of your teeth and gums tonight and tomorrow morning. If you brush your teeth both*

times, but not for long enough you will get a silver star, but no present'.

The child was then prompted to make the target statement, and was reminded to comply with it.

During the rest of this phase (a total of at least seven days) parents continued to set the occasion for the child to make the same promise before evening meals. Subjects who brushed well enough (met both the frequency and duration criteria) on both occasions (night and morning) were told that because they had fulfilled their promise they would be given a gold star and a reward. Children who brushed twice, but failed to brush for long enough on one or both occasions, were given feedback about their performance and a silver star, but no present. The consequences for brushing less than twice a day were the same as in the previous condition.

During this condition the experimenter examined the video recordings from each subject daily, and informed the parents whether their child had brushed twice that day for long enough on each occasion to be given a reward.

Maintenance of Correspondence

The calendars and stars were not used in this phase, but the parents were asked to select a few more presents. Material reward was delivered contingent on brushing teeth at an above-criterion level as described in the General Method. The criterion number of days of 'good' brushing was gradually increased, and prompting of the target verbalization was gradually faded as the number of days between intermittent consequences increased. In other words the children were only asked *'What are you going to do to keep your teeth healthy and clean?'* on days when they were given feedback about their cumulated performance.

As in the previous condition information about each subject's durations of toothbrushing was supplied to the parents by the experimenter.

Follow-up

In Follow-up 1 (4 days) parents were asked to behave as they had done since our last intervention. In some cases parents were occasionally present whilst the child brushed teeth, and some parents sometimes prompted their children to brush. Immediately after this, in Follow-up 2 (4 days), our more stringent baseline conditions applied (i.e. parents were asked not to prompt, or make any uninvited references to their child's toothbrushing).

RESULTS

Target Verbalizations

All the children, except Susan, always produced the target verbalization, *"Every night and every morning I will brush every part of all my teeth and gums"* when prompted. They were able to do this *without assistance* after the first two days of exposure to the Subject Verbalization condition.

On the first day Susan refused to say the word *"teeth"* for several minutes. On her first attempt she said, *"Every evening and every morning I'll brush every part of my **hair**"*. After this her typical verbalization was *"Every evening and every morning I'll brush every part of my gums and ...... my .... ah ...."* Susan made the statement perfectly well on the second and third afternoon, then repeated the words spontaneously on the third morning, and told her mother not to buy her another present that day. That afternoon (the fourth day) she refused to say the words, and was not given a gold star or a present. Susan made the statement the next morning and then demanded a gold star and a reward. Contrary to experimental instructions, Susan's mother gave her the star and a present. These incidents illustrate the magnitude of Susan's counter-control and the conflict in her interactions with her mother concerning toothbrushing. Susan's mother was counselled to follow the experimental procedures precisely, and to demonstrate that it was she, and not Susan, who was to determine the contingencies.

Frequency of Toothbrushing

The subjects' daily frequency of toothbrushing is presented in Figure 2.3.1, and Table 2.3.2 is a summary of the frequency data in each condition. During the Baseline condition (B) two subjects (Simon and Susan) brushed only once. The behaviour of the other three subjects (Sally, Helen and Frank) was more frequent but variable. Possible novelty effects can be seen in the data for two of the subjects: Sally brushed twice on the first day and once a day for the rest of the phase; Susan brushed once on the first evening and then not at all.

Simon and Susan did not brush their teeth at all during the Subject Verbalization phase (V), and there was little change in the toothbrushing frequencies of the other subjects. The introduction of the Frequency Correspondence Training condition (FC), however, resulted in clear and stable increases in frequency levels. Although four of the five subjects quickly increased their brushing to twice a day on most days, Susan's improvement was slower and more erratic. At first when she brushed it was generally only at night, but eventually after the twelfth day in this condition she began to brush regularly twice a day (on eight of the last eleven days of the phase, days 29 to 39).

Frequency of toothbrushing was extremely stable for all subjects throughout the Duration and Frequency Correspondence Training phase (DC). Only Sally and Simon ever brushed less than twice a day, but in all cases this was because they had been out for the day, and had fallen asleep before arriving home at night.

In the Maintenance condition (M) Sally continued to brush twice daily everyday for the fifteen days of recorded exposure, and all of the other subjects brushed much more frequently than they had done in the first two phases of the experiment (B & V). Helen, however, was not exposed to exactly the same contingencies as the other subjects. At the end of the Duration and Frequency Correspondence Training phase, in compliance with her parents wishes, it was decided that Helen would not receive any further material rewards. Throughout the Maintenance phase Helen was given feedback and praise on days when material rewards might otherwise be due.

Frequencies were well maintained during the first part of the follow-up phase (Fu1) which was conducted two months after the end of the Maintenance intervention. Three subjects (Sally, Helen and Frank) brushed twice a day every day. Simon and Susan both brushed once a day on average compared to once in fourteen and once in seventeen days respectively during the first two phases of the experiment. The behaviour was maintained in most cases when parents were prohibited from prompting during the second part of the follow-up phase (Fu2). Helen and Frank continued to brush twice a day on average, and Simon brushed once a day every day (mornings). Susan's behaviour remained variable, but she still maintained an average of once a day. Only Sally appears to have depended on constant reminders from her parents, because her frequency of brushing dropped to a very low level in Follow-up 2. In all other cases the frequency of toothbrushing was maintained at a level higher than in the Baseline and Subject Verbalization conditions.

Figure 2.3.1

Frequency of toothbrushing per day for each subject during Baseline (B), Subject Verbalization (V), Frequency Correspondence Training (FC), Duration and Frequency Correspondence Training (DC), Maintenance (M) and both two-month Follow-ups (Fu1 and Fu2).

Figure 2.3.1

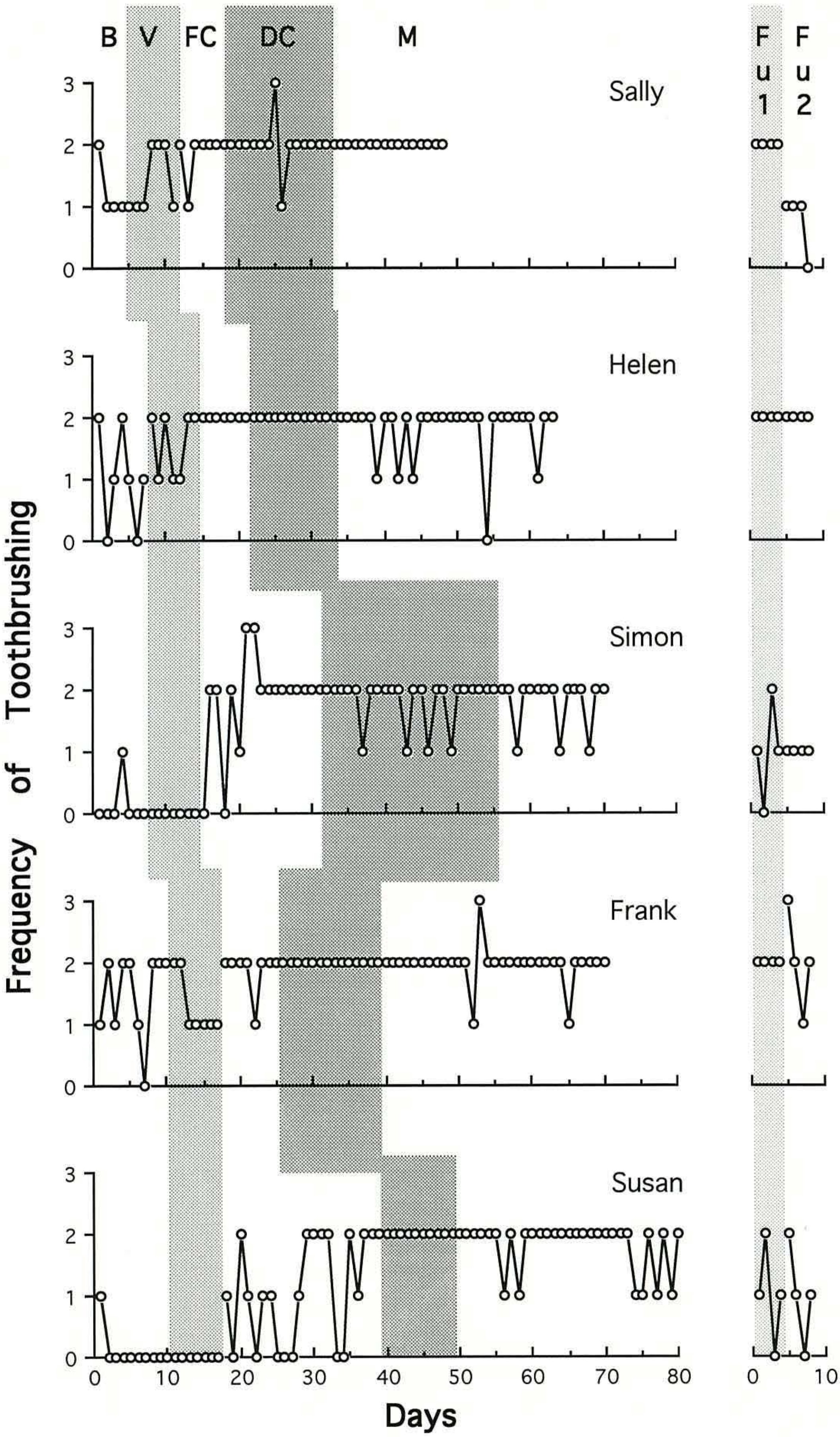

B
V
FC
DC
M
Fu1
Fu2
Sally
Helen
Simon
Frank
Susan
Frequency of Toothbrushing
Days
0
1
2
3
0
10
20
30
40
50
60
70
80
0
10

TABLE 2.3.2

Mean Frequency of Toothbrushing

Experiment 1.

Each subject's mean frequency of toothbrushing per day, standard deviation, number of observations (N), and range (min. & max. values) in each condition: Baseline (B), Subject Verbalization (V), Frequency Correspondence Training (FC), Duration and Frequency Correspondence Training (DC), Maintenance (M) and both two-month Follow-ups (Fu1 & Fu2).

Subjects and Measures	Experimental Conditions						
	B	**V**	**FC**	**DC**	**M**	**Fu1**	**Fu2**
Sally							
Mean	1.25	1.43	1.86	2.00	2.00	2.00	0.75
Std D	0.50	0.54	0.38	0.39	0	0	0.50
N	4	7	7	14	16	4	4
Range	1 - 2	1 - 2	1 - 2	1 - 3	2 - 2	2 -2	0 - 1
Helen							
Mean	1.00	1.57	2.00	2.00	1.80	2.00	2.00
Std D	0.82	0.54	0	0	0.48	0	0
N	7	7	7	12	30	4	4
Range	0 - 2	1 - 2	2 - 2	2 - 2	0 - 2	2 - 2	2 - 2
Simon							
Mean	0.14	0	1.82	1.83	1.80	1.00	1.00
Std D	0.38	0	0.81	0.38	0.42	0.82	0
N	7	7	17	24	15	4	4
Range	0 - 1	0 - 0	0 - 3	1 - 2	1 - 2	0 - 2	1 - 1
Frank							
Mean	1.50	1.29	1.88	2.00	1.97	2.00	2.00
Std D	0.71	0.49	0.35	0	0.32	0	0.82
N	10	7	8	14	31	4	4
Range	0 - 2	1 - 2	1 - 2	2 - 2	1 - 3	2 - 2	1 - 3
Susan							
Mean	0.10	0	1.09	2.00	1.81	1.00	1.00
Std D	0.32	0	0.87	0	0.40	0.82	0.82
N	10	7	22	10	31	4	4
Range	0 - 1	0 - 0	0 - 2	2 - 2	1 - 2	0 - 2	0 - 2

Duration of Toothbrushing per Occasion

Figure 2.3.2 is a plot of each subject's mean duration of toothbrushing per occasion per day. It is a representation of the amount of time subjects tended to spend brushing their teeth during each brushing event irrespective of how frequently they brushed. Presented in Table 2.3.3 is a summary of the daily mean duration per occasion data in each condition.

Sally's mean duration per occasion was 10 seconds or less on three of the four days of Baseline (B). Helen and Frank tended to brush for slightly longer. Susan brushed only once for 21 seconds, and Simon's single attempt was one of great duration (152 secs.). This event is accounted for by his mother, who noted in her diary that day (Day 4), that Simon was expecting to be with his grandmother, whom he doesn't see very often and is a stickler for dental hygiene. Mean durations per occasion did not change sytematically after the introduction of the Subject Verbalization condition (V).

Although all the subjects increased their frequency of toothbrushing during the Frequency Correspondence Training phase (FC), this condition had little effect on the mean duration per occasion of children who had brushed their teeth in both of the previous phases (i.e. Sally, Helen and Frank). In fact both Helen and Frank tended to spend less time brushing their teeth per occasion in this condition than they had done in Baseline.

Figure 2.3.2

Mean duration of toothbrushing per occasion per day for all subjects during Baseline (B), Reinforcement of Verbalizaton (V), Frequency Correspondence Training (FC), Duration and Frequency Correspondence Training (DC), Maintenance (M) and both two month Follow-ups (Fu1 and Fu2). These data were calculated by totalling the recorded evening and morning durations, then dividing this sum by the daily frequency. A missing data point indicates that no duration recording was taken on that day, either because of video equipment failure, or because the toothbrushing frequency was zero. On the few occasions when a subject was known to have brushed more than once, but it was possible only to score one duration accurately, this one duration was used as the mean for that day.

Figure 2.3.2

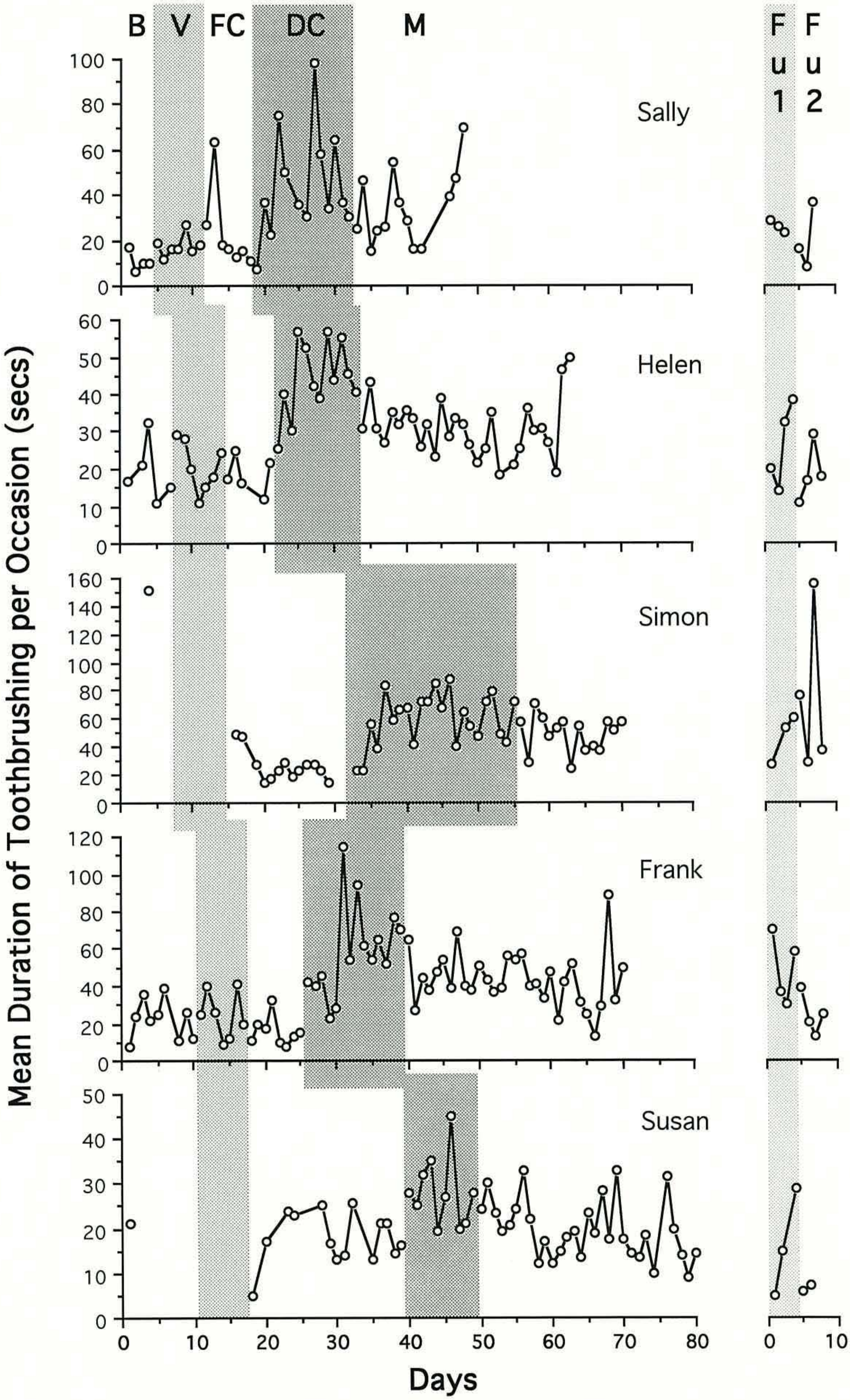

B
V
FC
DC
M
Fu1
Fu2
Sally
Helen
Simon
Frank
Susan
Mean Duration of Toothbrushing per Occasion (secs)
Days

TABLE 2.3.3

Mean Duration of Toothbrushing per Occasion

Experiment 1

Each subject's mean duration of toothbrushing per occasion, standard deviation, number of observations (N), and range (min. & max. values) in each condition: Baseline (B), Subject Verbalization (V), Frequency Correspondence Training (FC), Duration Correspondence Training (DC), Maintenance (M) and both two-month Follow-ups (Fu1 & Fu2).

Subjects and Measures	Experimental Conditions						
	B	**V**	**FC**	**DC**	**M**	**Fu1**	**Fu2**
Sally							
Mean	10.75	17.50	23.21	44.37	34.27	25.83	20.33
Std D	4.57	4.56	18.29	24.21	16.69	2.75	14.98
N	4	7	7	13	13	3	3
Min	6.00	12.00	11.00	7.00	15.00	23.00	8.00
Max	17.00	26.50	63.00	98.00	70.00	28.50	37.00
Helen							
Mean	19.30	20.79	18.40	44.00	30.88	26.25	18.63
Std D	8.21	6.72	5.02	10.13	7.59	11.23	7.54
N	5	7	5	12	29	4	4
Min	11.00	11.00	12.00	25.50	18.50	14.00	11.00
Max	32.50	29.00	25.00	57.00	50.00	38.50	29.00
Simon							
Mean	*	*	26.28	59.37	49.20	47.00	74.25
Std D	*	*	10.95	18.66	12.73	17.78	57.62
N	1	*	13	23	15	3	4
Min	*	*	14.00	22.50	25.00	27.00	29.00
Max	*	*	49.00	88.00	70.00	61.00	155.00
Frank							
Mean	22.56	24.57	15.81	58.61	43.37	48.88	24.46
Std D	10.77	12.47	7.81	24.95	15.07	18.59	11.08
N	9	7	8	14	31	4	4
Min	8.00	8.50	8.00	22.50	12.50	30.00	13.00
Max	39.00	41.00	32.50	115.00	89.00	70.00	39.33
Susan							
Mean	*	*	17.75	28.05	19.63	16.33	6.50
Std D	*	*	5.80	7.81	6.68	12.06	0.71
N	1	*	14	10	30	3	2
Min	*	*	5.00	19.50	9.00	5.00	6.00
Max	*	*	25.50	45.00	33.00	29.00	7.00

* Indicates that there are insufficient occasions of brushing for meaningful data analysis.

Marked increases in toothbrushing durations were seen in all cases after the introduction of the Duration and Frequency Correspondence Training condition (DC). Each child's average mean duration per occasion was now more than double the levels in Baseline or the Subject Verbalization condition. Mean duration levels in the Maintenance phase (M) were lower than in the Duration and Frequency Correspondence Training condition, but they were generally higher than in any other phase.

Two months later, in the first follow-up (Fu1), mean durations per occasion were generally well above the levels recorded during Baseline or Subject Verbalization. Duration levels fell in 4 out of 5 cases during the second follow-up condition (Fu2). This may indicate that although whether most children brushed or not did not depend on parental reminders, a display of parental interest in the children's brushing did affect how long they spent on their teeth. Simon's results appear to contradict this, but in fact his mother, consistent with her practices prior to Follow-up, did not to remind Simon to brush in either condition.

Total Duration of Toothbrushing

Figure 2.3.3 represents each subject's total duration of toothbrushing each day, and so each data point combines the frequency of brushing per day and the duration of each brushing event. Figure 2.3.4 depicts an overall summary of each subject's data for each phase in Experiment 1, on the left is the mean frequency of toothbrushing per day, and on the right is the mean total duration of brushing per day. The means for evening and morning sessions in each phase are also shown. Presented in Table 2.3.4 are the difference scores between the Baseline mean total duration per day and the mean total duration per day in each of the subsequent phases, expressed as a percentage of the Baseline duration.

Apart from Simon, only Helen ever spent more than a total of 60 seconds on her teeth in any one day in Baseline (B). The introduction of the Subject Verbalization condition (V) did not result in any systematic change in frequency or total duration levels. Frank's mean total duration per day was almost the same as it was in Baseline, Simon and Susan did not brush their teeth at all in this condition, whereas Sally and Helen improved their mean total duration per day by 72% and 62% respectively. Although all the subjects clearly increased their frequency of toothbrushing during the Frequency Correspondence Training phase (FC), this condition had little effect on the total daily durations of Helen and Frank, because as noted earlier, they tended to spend less time on each occasion that they brushed (see Table 2.3.3).

All the children more than doubled the average amount of time they spent brushing their teeth each day when exposed to the Duration and Frequency Correspondence contingencies (DC). Improvements over Baseline ranged between 263% and 2513% (see Table 2.2.4). Duration levels were not quite as good after the introduction of the Maintenance condition (M), but overall they remained at a higher level than in any phase previous to Duration Correspondence Training. Despite the general drop in duration levels at the two month Follow-up, only Sally's and Helen's mean total durations per day were not substantially higher in Follow-up 2 than in the first two phases of the study (B & V).

Figure 2.3.3

Total duration of toothbrushing per day for all subjects during Baseline (B), Reinforcement of Verbalizaton (V), Frequency Correspondence Training (FC), Duration and Frequency Correspondence Training (DC), Maintenance (M) and both two month Follow-ups (Fu1 and Fu2). Data for this figure were calculated by totalling known durations of all toothbrushing events that occurred on each day. There are missing data points on days when it was not possible to record an accurate duration for one or more of the toothbrushing events, because, for example, there was not enough light in the bathroom, the subject brushed off-camera, or the equipment failed to record the subjects' behaviour.

Figure 2.3.3

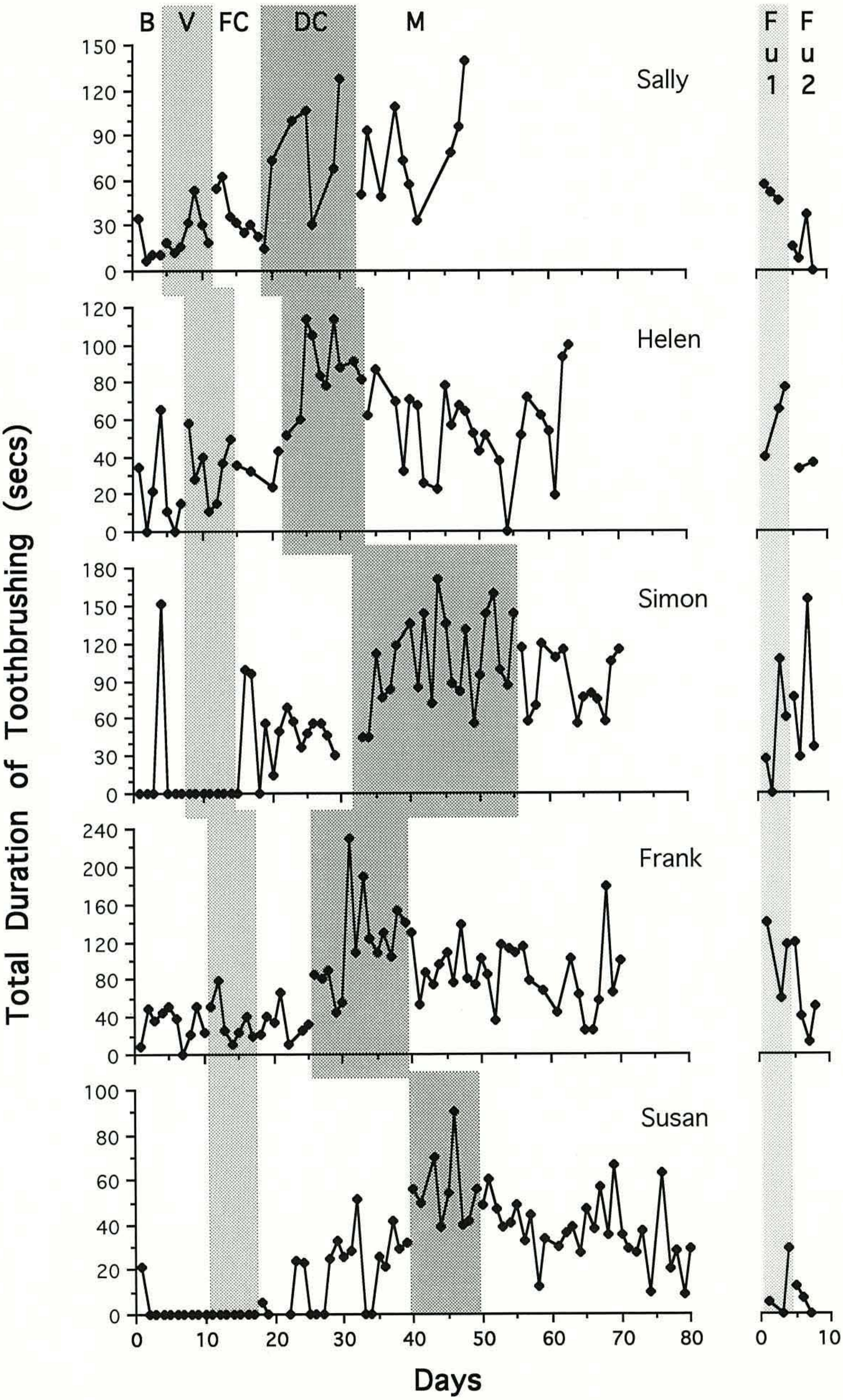

B
V
FC
DC
M
Fu1
Fu2
Sally
Helen
Simon
Frank
Susan
Total Duration of Toothbrushing (secs)
Days
0
10
20
30
40
50
60
70
80

Figure 2.3.4

The mean frequency of toothbrushing per day (left side) and the mean total duration of brushing per day (right side) for each subject in each of the phases: Baseline (B), Reinforcement of Verbalizaton (V), Frequency Correspondence Training (FC), Duration and Frequency Correspondence Training (DC), Maintenance (M) and both two-month Follow-ups (Fu1 and Fu2). The means for evening (light diagonal line shading) and morning sessions (dark diagonal line shading) in each phase are also shown. Data for the frequency graph (left side) were calculated by totalling the number of brushing events that occurred at night and in the morning, and dividing by the total number of days in the phase. Data for the duration graph were calculated by totalling all the subjects' known durations at night and in the morning in each phase, and dividing by the total number of sessions (of known duration) in the phase.

Figure 2.3.4

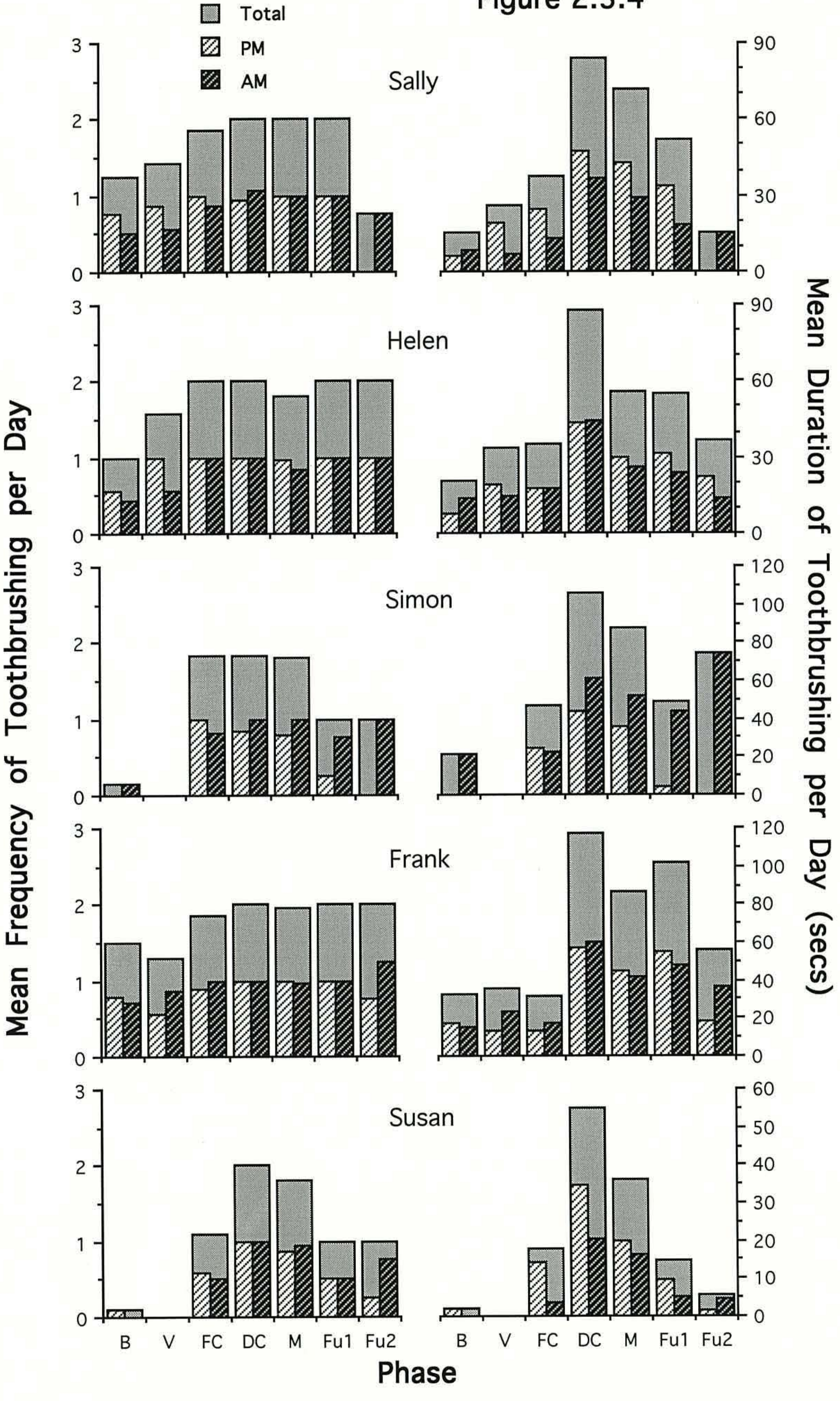

Total
PM
AM
Sally
Helen
Simon
Frank
Susan
Mean Frequency of Toothbrushing per Day
Mean Duration of Toothbrushing per Day (secs)
B
V
FC
DC
M
Fu1
Fu2
Phase

TABLE 2.3.4

Mean Total Duration Difference Scores

Experiment 1

The percentage difference between each subject's Baseline mean total duration per day and his/her mean total duration per day in all subsequent phases: Subject Verbalization (V), Frequency Correspondence Training (FC), Duration and Frequency Correspondence Training (DC), Maintenance (M) and both two-month Follow-ups (Fu1 & Fu2).

Subjects and Sessions	Experimental Condition					
	V	FC	DC	M	Fu1	Fu2
Sally						
PM	202%	289%	654%	583%	433%	-84%
AM	-22%	50%	321%	235%	110%	74%
Total	**72%**	**250%**	**459%**	**380%**	**244%**	**1.7%**
Helen						
PM	167%	144%	495%	310%	328%	207%
AM	6%	29%	224%	92%	74%	3%
Total	**62%**	**69%**	**319%**	**168%**	**163%**	**74%**
Simon						
PM	0	2353%	4317%	3421%	350%	0
AM	-95%	47%	183%	140%	103%	242%
Total	**-95%**	**118%**	**386%**	**302%**	**123%**	**242%**
Frank						
PM	-26%	-20%	231%	160%	218%	9%
AM	53%	15%	300%	174%	215%	143%
Total	**11%**	**-3.7%**	**263%**	**167%**	**216%**	**72%**
Susan						
PM	-52%	582%	1552%	849%	360%	71%
AM	0	235%	1922%	1513%	400%	333%
Total	**-52%**	**741%**	**2513%**	**1618%**	**598%**	**178%**

Percentage difference was calculated by using the following formula:

$$\textbf{Percentage difference} = \left\{ \frac{\textit{Phase Mean}}{\textit{Baseline Mean}} - 1 \right\} \times 100$$

Where *Baseline Mean* **= Mean total duration per day in Baseline**

and *Phase Mean* **= Mean total duration per day in any phase other than Baseline**

Any Phase Mean value of zero was assigned a nominal value of 1 second to enable a calculation to be made.

The interventions clearly affected frequency and duration of toothbrushing both at night and in the mornings, but evening brushings were affected most during training (see Table 2.3.4). After training however, during Follow-up 2, four of the five children brushed more frequently in the morning than at night (Sally and Simon did not brush their teeth at all in the evenings during this condition). The duration data for these children confirms that improvements over Baseline were better maintained in the morning than at night.

DISCUSSION

In this experiment parents, supervised by the experimenter, have successfully implemented a 'say-do' correspondence training procedure that was designed to promote the frequency and duration of their children's toothbrushing. Consistent with the literature, and as expected, the Subject Verbalization condition effectively promoted increases in children's overt verbalizations of the target rule, but it had little or no effect on the frequency and duration of their toothbrushing. The children brushed more frequently when rewards were made contingent on both stating the rule and brushing twice each day, but this condition (Frequency Correspondence Training) did not lead to uniform substantial increases in the subject's total durations of toothbrushing per day. There were clear improvements in brushing durations only when rewards were explicitly made contingent upon the children stating the rule, brushing twice a day, and increasing the amount of time they spent brushing their teeth on each occasion (Duration and Frequency Correspondence Training). These effects were well maintained during a phase in which an attempt was made to introduce more naturally occurring social consequences for the target behaviour whilst sytematically fading out the experimenter-imposed contingencies (Maintenance). Performance during the two-month Follow-ups was variable, but in general the subjects brushed their teeth more frequently and for longer than they had done in Baseline.

An unusual feature of this experiment was that 'saying' referred to two temporally-separate instances of 'doing'. During correspondence training the children were prompted to say the rule in the afternoon (generally after school but before the evening meal), and were not given feedback or rewards for their behaviour until the following afternoon. It was found that although the training affected the non-verbal behaviour (toothbrushing) both in the evening, after the statement of the rule, and the following morning, the level of evening toothbrushing was affected most. This result can be interpreted in terms of 'near' and 'far' correspondence between verbal and non-verbal behaviour. A study with 4 to 5 year olds has shown that when a contingency specifying instruction was followed immediately by an opportunity to engage in the specified behaviour, the instruction reliably controlled this behaviour, but when the opportunity to respond was delayed, it did not (Mistr, 1992, quoted in Schlinger, 1993). During training in the current experiment, the temporal distance between the prompted verbalization of the rule and the evening brushing (between 2 and 5 hours) was much less than that between statement of the rule and the morning brushing (normally between 14 and 19 hours), and this difference in delay may account for the difference in effect.

Correspondence training did, nevertheless, lead to substantial improvements in the level of morning toothbrushing, and at the two-month Follow-up, when parents were prohibited from prompting (in Follow-up 2), the children generally brushed more frequently and for longer in the morning than they did at night. Treatment effects on morning brushing may be better maintained, because of the presence of a discriminative cue for toothbrushing that occurs naturally in the morning, but not at night. Such a cue might be the parents' toothbrushing behaviour. Children are likely to see or be aware of their parents brushing their teeth in the mornings, but they usually go to bed before their parents and would normally be asleep when their parents brush at night. It may be that during training, the function of certain naturally occurring events in the evenings was altered by the temporally proximate overt verbalization of the rule (see Schlinger, 1993), so that these events acted as discriminative stimuli for rule following (toothbrushing). During Follow-up, however, because the children were no longer prompted to state the rule in the afternoons, these events no longer functioned as discriminative stimuli for toothbrushing.

2.4. EXPERIMENT 2

The aim of the second experiment was to examine whether a compliance procedure, in which the subjects were **never** required to make an overt verbalization of intent, would establish behaviour as effectively as correspondence training. This experiment was procedurally very similar to the first except that the children were never rewarded for 'saying', and parental instructions about contingencies replaced child 'promises'. The procedure differs from those used by other researchers who have compared correspondence and compliance methods (e.g. Baer, Detrich & Weninger, 1988; Deacon & Konarski, 1987; Ward & Stare, 1990), because all the subjects in those experiments were exposed to a condition in which they were rewarded for 'saying' before exposure to either a correspondence or compliance condition.

A comparison of the effects of this procedure with those of Experiment 1 during (i) intensive training, (ii) the maintenance condition, and (iii) the two month follow-ups, will provide a more thorough test than any yet reported in the literature concerning the relative practical utility of the correspondence and compliance training procedures.

METHOD

PARTICIPANTS

(a) **Subjects**

Five children participated. They were two girls (Milly and Karen) and three boys (Noel, Raymond and Donald). Their mean age was five years eleven months, compared to a mean of five years nine months in Experiment 1. Three of the subject's in this experiment, and none in Experiment 1, had younger siblings (see Table 2.4.1 for complete subject and sibling details).

(b) **Parents**

In four of the families the subject's mother administered all of the interventions. In Donald's family this role was shared between both parents.

DEPENDENT VARIABLES AND RECORDING

(a) **Target Behaviours**

The dependent variables were (i) toothbrushing frequency, and (ii) toothbrushing duration, which were assessed in exactly the same way as in Experiment 1.

(b) **Reliability**

The correlations between the two observers measures of toothbrushing durations in each condition were close to +1.00 in all cases, indicating reliable covariation. For all the subjects combined, the overall correlation was, 0.989; for Karen, 0.990;

TABLE 2.4.1

AGE OF SUBJECTS AND THEIR SIBLINGS

EXPERIMENT 2

Subject	Age at Start	Number of Siblings	Age of Siblings
Karen	6 yrs 2 mths	0	-
Noel	5 yrs 10 mths	1	2 yrs
Donald	5 yrs 9 mths	1	3 yrs
Raymond	5 yrs 11 mths	0	-
Milly	6 yrs 0 mths	1	2 yrs

Mean age of subjects at start = 5 yrs 11 mths

Noel, 0.992; Donald, 0.983; Raymond, 0.995; and Milly, 0.987. The overall agreement calculated by the Frequency Ratio method was 98.2%. Agreement for Karen averaged 97.8%; for Noel, 99.3%; Donald, 98.9%; Raymond, 98.1%; and Milly, 96.9%. This indicates that the degree of absolute agreement between observers' estimates of duration was very good.

Experimental Design

Baselines in Experiment 2 were six days (Karen and Noel), nine days (Donald), and twelve days (Raymond and Milly). After baseline the subjects were sequentially exposed to three intervention conditions:
(1) Frequency Compliance Training
(2) Duration and Frequency Compliance Training
(3) Maintenance of Compliance.

Procedure

Frequency Compliance Training

The token reinforcement system used in Experiment 1 was introduced on the first day of this condition. On the first afternoon parents said to the subject (in the bathroom with the toothbrush removed):

> *'You know, you should brush your teeth twice a day. Once at night before you go to bed, and once in the morning after breakfast. Every time you clean your teeth, you should be careful to brush your gums as well as every part of every tooth. I am not going to*

help you to do this, you will have to remember to do it yourself.'

After this the parent put a gold star on the calendar, gave the child a present, and said:

'Tomorrow afternoon, if you have remembered to brush your teeth tonight before you go to bed ***and*** *tomorrow morning after breakfast, I will give you another gold star to put on this calendar, and I will give you another present. If you only remember to brush your teeth once, I will give you a green star for the calendar, but no present. So remember, if you want a gold star and a present, you have to remember to brush your teeth both times. I am not going to remind you, okay.'*

The next day (and on each of the other six or more days during this condition) children who had brushed teeth the previous night and in the morning were praised and told:

'Yesterday I said that you should brush every part of all of your teeth and gums every night and every morning. You did brush your teeth last night ***and*** *this morning, so here is a gold star for your calendar. I also have a present for you'.*

A child who brushed only once would be reminded of the occasion that had been forgotten, and given a green star but no present. A child who did not brush at all was given no star or present, but was encouraged to try to remember the next time. All the children were then told:

'Remember that you should brush every part of all of your teeth and gums every night and every morning. If you brush your teeth tonight and tomorrow morning, I will give you a gold star and a present at this same time tomorrow'.

Duration and Frequency Compliance Training

This intervention was introduced only when the children brushed twice each day consecutively for at least three days. Parents were given more toys chosen from the catalogue, and some silver adhesive stars. Rewards were given contingent upon the children brushing twice each day for longer durations per occasion than before. A predetermined criterion was adopted for each child and this was adjusted in order to shape up increasing duration of toothbrushing. The only difference between this condition and the 'Duration Correspondence Training' phase of Experiment 1 was that the child was *not* required to make the overt verbalization. Instead, the parent simply instructed the child about the contingency.

Before the evening meal on the first afternoon of this phase, after the child had been given feedback and rewards for brushing twice on the previous day, the parent looked into the child's mouth and said:

'Remember that I have been saying that you should brush ***every*** *part of* ***all*** *of your teeth and gums. You have been brushing your teeth every night and every*

morning, but tomorrow I will only give you a gold star and a present if you brush ***every*** *part of* ***all*** *of your teeth and gums both times. If you brush your teeth both times, but not well enough you will get a silver star, but no present'.*

On the following afternoons in this phase, if a child had brushed for long enough on both occasions, the parent praised the child, then gave a gold star and a reward. A child who brushed twice, but failed to brush for more than the predetermined period of time on one or both occasions, would be given a silver star and feedback about the performance. The consequences for brushing less than twice a day were the same as in the previous condition.

Maintenance of Compliance

As in Experiment 1 the calendars and stars were not used in this phase, but the parents were asked to select a few more presents. The procedure was very similar except that consistent with the overall differences between the experiments, parental instructions replaced the subjects' prompted overt verbalizations of the rule. Instructions and material rewards were faded in the same sytematic fashion as in Experiment 1, so that the the instruction to *'brush every part of all of your teeth and gums every night and every morning'* was only given on days when the children were given feedback about their performance.

Follow-up

Follow-up procedures were exactly the same as those in Experiment 1.

RESULTS

Frequency of Toothbrushing

Figure 2.4.1 shows the frequency of toothbrushing per day for all subjects throughout the study, and Table 2.4.2 is a summary of the frequency data in each condition. During Baseline (B) it can be seen that daily frequency of brushing varied greatly both within and between subjects, and that none of the subjects brushed regularly twice a day. When the Frequency Compliance condition (FC) was introduced toothbrushing frequency increased in all cases and was maintained at well above Baseline levels. Karen and Milly each brushed twice a day on every day except for two, whilst Noel and Donald failed to brush twice on only three occasions. Raymond brushed twice a day for the first six days of the phase, but his behaviour lapsed on the seventh day (day 19) when he had his birthday party. It is possible that at this time, because of the abundance of birthday presents, the contingent material rewards may have become less reinforcing. Raymond's behaviour eventually stabilized at twice a day every day during the last four days of the phase.

Frequency levels remained high in the Duration Compliance (DC) and Maintenance (M) conditions. All of the subjects brushed twice or more on most of the days in these phases. Both Karen and Milly brushed teeth twice a day on every day of the two parts of the Follow-up phase (Fu1 & Fu2) even though their parents did not prompt them to brush teeth at all in either condition. The other subjects also brushed their teeth far more frequently during both Follow-up conditions than they had done in the Baseline.

Figure 2.4.1

Daily frequency of toothbrushing for each subject during Baseline (B), Frequency Compliance Training (FC), Duration and Frequency Compliance Training (DC), Maintenance (M) and both two-month Follow-ups (Fu1 and Fu2).

Figure 2.4.1

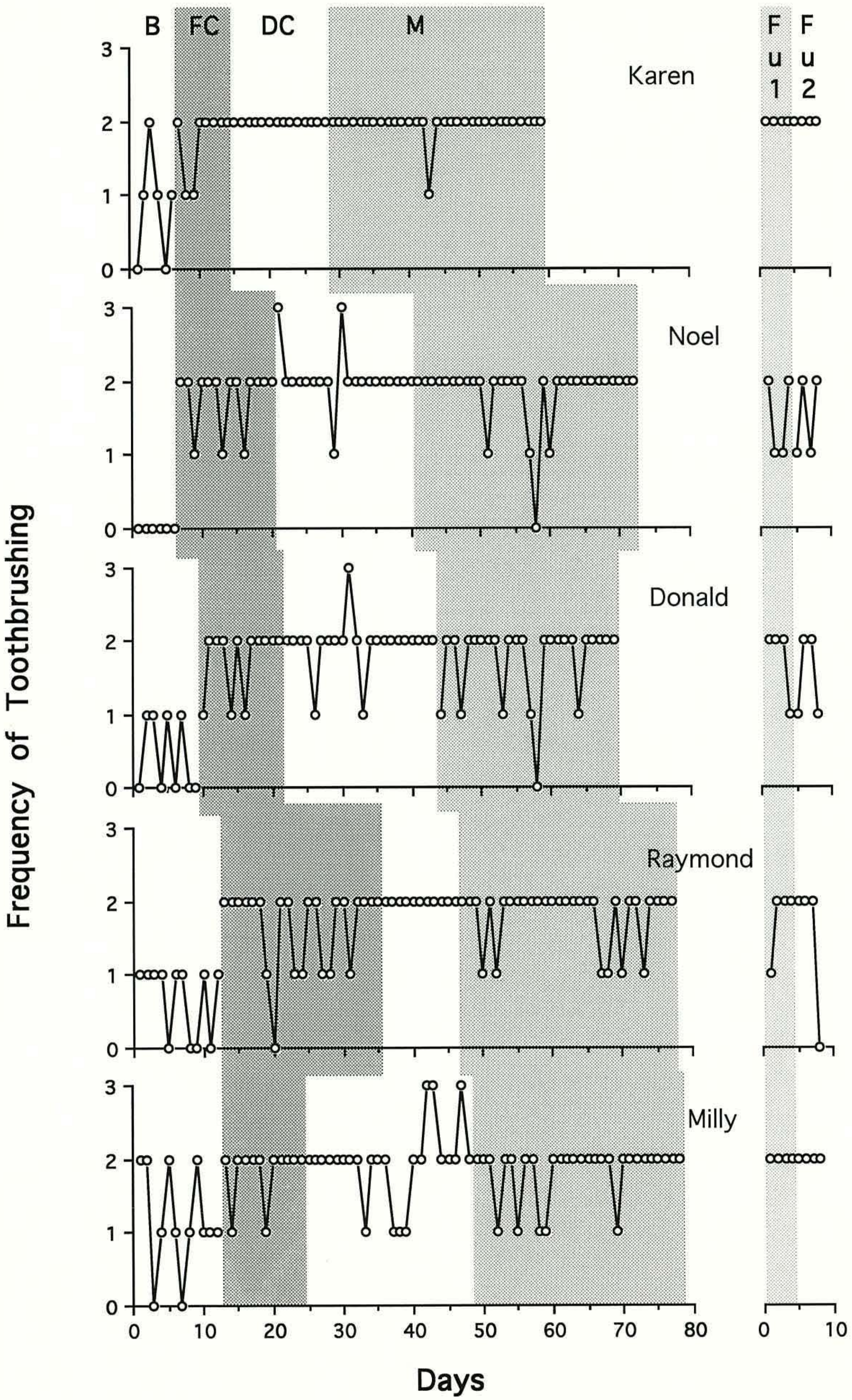

B
FC
DC
M
Fu1
Fu2
Karen
Noel
Donald
Raymond
Milly
Frequency of Toothbrushing
Days
0
10
20
30
40
50
60
70
80
0
10
0
1
2
3

TABLE 2.4.2

Mean Frequency of Toothbrushing

Experiment 2

Each subject's mean frequency of toothbrushing per day, standard deviation, number of observations, and range (min. & max. values) in each condition: Baseline (B), Frequency Compliance Training (FC), Duration and Frequency Compliance Training (DC), Maintenance (M) and both two-month Follow-ups (Fu1 & Fu2).

Subjects and Measures	Experimental Conditions					
	B	**FC**	**DC**	**M**	**Fu1**	**Fu2**
Karen						
Mean	0.83	1.75	2.00	1.97	2.00	2.00
Std D	0.75	0.46	0	0.18	0	0
N	6	8	14	31	4	4
Range	0 - 2	1 - 2	2 - 2	1 - 2	2 - 2	2 - 2
Noel						
Mean	0	1.79	2.05	1.84	1.50	1.50
Std D	0	0.43	0.39	0.45	0.58	0.58
N	6	14	20	32	4	4
Range	0 - 0	1 - 2	1 - 3	0 - 2	1 - 2	1 - 2
Donald						
Mean	0.44	1.75	1.96	1.73	1.75	1.50
Std D	0.53	0.45	0.38	0.53	0.50	0.58
N	9	12	22	26	4	4
Range	0 - 1	1 - 2	1 - 3	0 - 2	1 - 2	1 - 2
Raymond						
Mean	0.67	1.64	2.00	1.81	1.75	1.50
Std D	0.49	0.58	0	0.40	0.50	1.00
N	12	22	12	31	4	4
Range	0 - 1	0 - 2	2 - 2	1 - 2	1 - 2	0 - 2
Milly						
Mean	1.17	1.83	1.96	1.83	2.00	2.00
Std D	0.72	0.39	0.55	0.38	0	0
N	12	12	24	30	4	4
Range	0 - 2	1 - 2	1 - 3	1 - 2	2 - 2	2 - 2

Duration of Toothbrushing per Occasion

The data in Figure 2.4.2 represents each subject's mean duration of toothbrushing per occasion per day, calculated in the same way as the data for Experiment 1 Figure 2.3.2. Table 2.4.3 is a summary of the daily mean duration per occasion data in each condition.

Although all the subjects increased their frequency of toothbrushing after the introduction of the Frequency Compliance contingencies (FC), three of the four subjects who had brushed their teeth in Baseline (Donald, Raymond, and Milly) tended to spend less time brushing their teeth on each occasion during this second phase. There were substantial systematic increases in mean durations per occasion for most subjects after the introduction of the Duration Compliance contingencies (DC). Raymond was brushing almost three times more frequently in this condition than in Baseline, but his average mean duration per occasion (38.63 secs), although higher than the level in the previous condition (26.61 secs), was not as high as the Baseline (47.75 secs). Three of the children (Karen, Noel, and Milly) brushed for considerably longer on most occasions in the Maintenance condition (M) than they had done in either of the first two phases of the experiment (B & FC). Noel and Milly maintained duration per occasion levels in the Follow-ups (Fu1 & Fu2) that were notably better than the levels during Frequency Correspondence Training and Baseline. Although Milly brushed twice a day every day during both Follow-up conditions, she tended to spend much less time when her parents were prohibited from prompting in the second Follow-up phase (Fu2). The average mean duration per occasion for two of the other subjects (Karen and Donald) was also lower in the second Follow-up than in the first.

Figure 2.4.2

Mean duration of toothbrushing per occasion per day for all subjects during Baseline (B), Frequency Compliance Training (FC), Duration and Frequency Compliance Training (DC), Maintenance (M) and Follow-ups (Fu1 and Fu2). These data were calculated by totalling the recorded evening and following morning durations, then dividing this sum by the daily frequency.

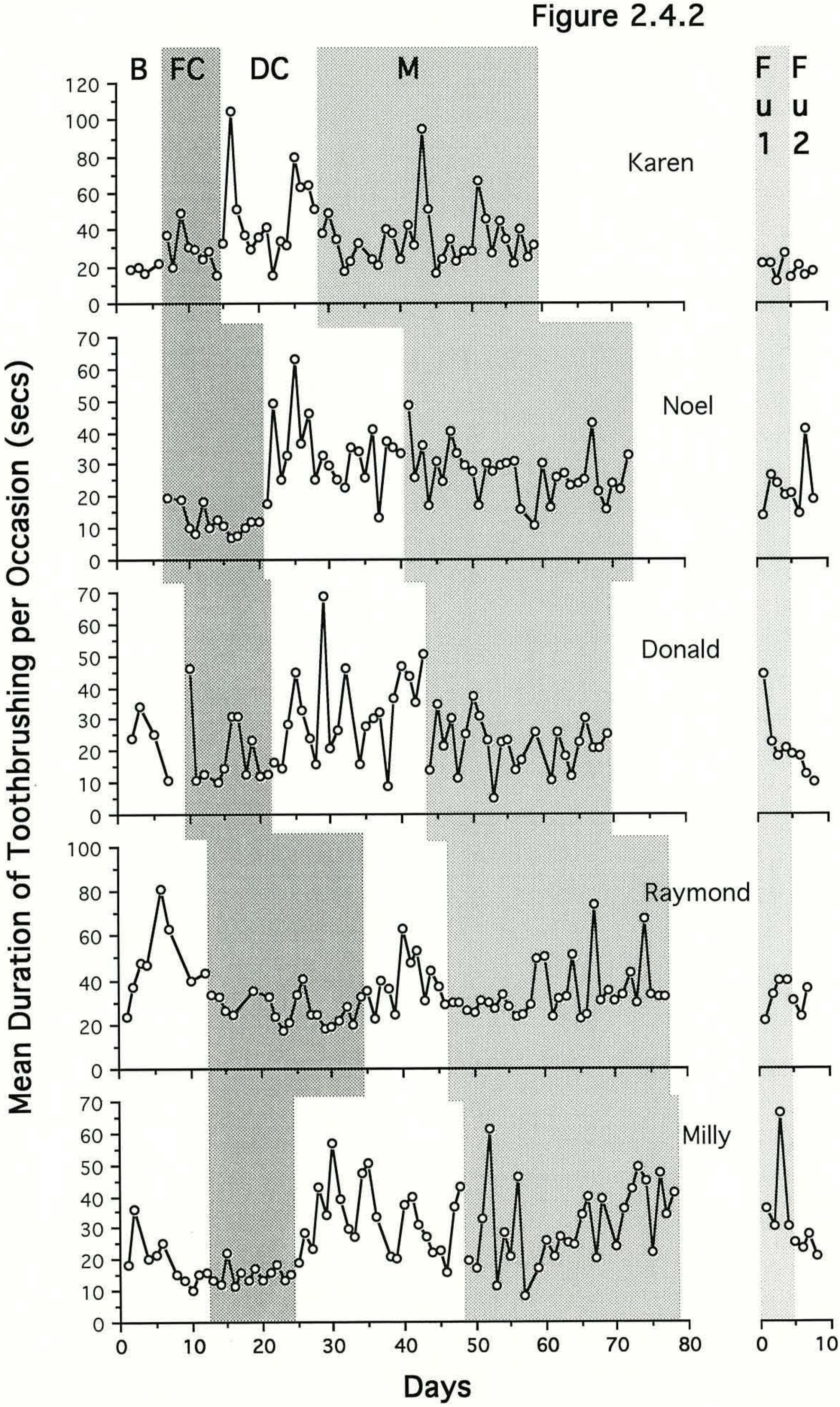


Figure 2.4.2
B
FC
DC
M
Fu 1
Fu 2
Karen
Noel
Donald
Raymond
Milly
Mean Duration of Toothbrushing per Occasion (secs)
Days

TABLE 2.4.3

Mean Duration of Toothbrushing per Occasion

Each subject's mean duration per occasion, standard deviation, number of observations (N), and range (min. & max. values) in each condition: Baseline (B), Frequency Compliance Training (FC), Duration and Frequency Compliance Training (DC), Maintenance (M) and both two-month Follow-ups (Fu1 and Fu2).

Subjects and Measures	Experimental Conditions					
	B	**FC**	**DC**	**M**	**Fu1**	**Fu2**
Karen						
Mean	19.13	29.19	48.11	35.20	20.38	17.13
Std D	2.46	10.39	23.48	15.98	6.46	2.70
N	4	8	14	30	4	4
Min	16.00	15.50	15.50	16.00	11.50	14.50
Max	22.00	49.00	105.00	95.00	27.00	20.50
Noel						
Mean	*	12.08	33.07	27.03	21.13	23.88
Std D	*	4.20	11.25	8.25	5.45	11.74
N	0	13	20	31	4	4
Min	*	7.00	13.50	11.00	14.00	14.50
Max	*	19.50	63.00	48.50	26.50	41.00
Donald						
Mean	23.50	19.64	31.68	21.75	26.63	14.88
Std D	9.47	11.76	14.60	7.95	11.73	4.33
N	4	11	21	24	4	4
Min	11.00	10.00	9.00	5.00	18.50	10.00
Max	34.00	46.00	68.50	37.00	44.00	19.00
Raymond						
Mean	47.75	26.61	38.63	34.26	33.50	30.00
Std D	17.52	6.73	12.06	12.27	8.26	6.56
N	8	19	12	31	4	3
Min	23.00	17.00	22.50	22.50	22.00	23.00
Max	81.00	40.50	63.50	74.00	39.50	36.00
Milly						
Mean	18.95	14.96	32.55	30.70	40.63	24.25
Std D	7.39	3.00	10.90	12.69	17.13	2.72
N	10	12	23	28	4	4
Min	10.00	11.50	16.00	8.00	30.00	21.00
Max	36.00	22.00	57.00	61.00	66.00	27.50

* Indicates that there are insufficient occasions of brushing for meaningful data analysis.

Total Duration of Toothbrushing

Figure 2.4.3 represents each subject's total duration of toothbrushing each day, Figure 2.4.4 depicts an overall summary of each subject's data for each phase in Experiment 2 (on the left, mean frequency of toothbrushing per day, and on the right, mean total duration of brushing per day). Presented in Table 2.4.4 are the difference scores between the Baseline mean total duration per day and the mean total duration per day in each subsequent phase, expressed as a percentage of the Baseline duration

It can be seen that the daily total durations varied within and between subjects during Baseline (B). Although all the subjects clearly increased their frequency of toothbrushing during the Frequency Compliance Training phase (FC), this condition had little effect on the total daily durations of Raymond and Milly, because as stated previously, they tended to spend less time on each occasion that they brushed (see Table 2.4.3). Total durations improved substantially after the introduction of the Duration Compliance contingencies (DC), so that in this condition, all the children spent on average more than double the amount of time they had spent brushing their teeth each day in the two previous phases.

Figure 2.4.3

Total duration of toothbrushing per day for all subjects during Baseline (B), Frequency Compliance Training (FC), Duration and Frequency Compliance Training (DC), Maintenance (M) and Follow-ups (Fu1 and Fu2). Data for this figure were calculated by totalling known durations of all toothbrushing events that occurred on each day.

Figure 2.4.3

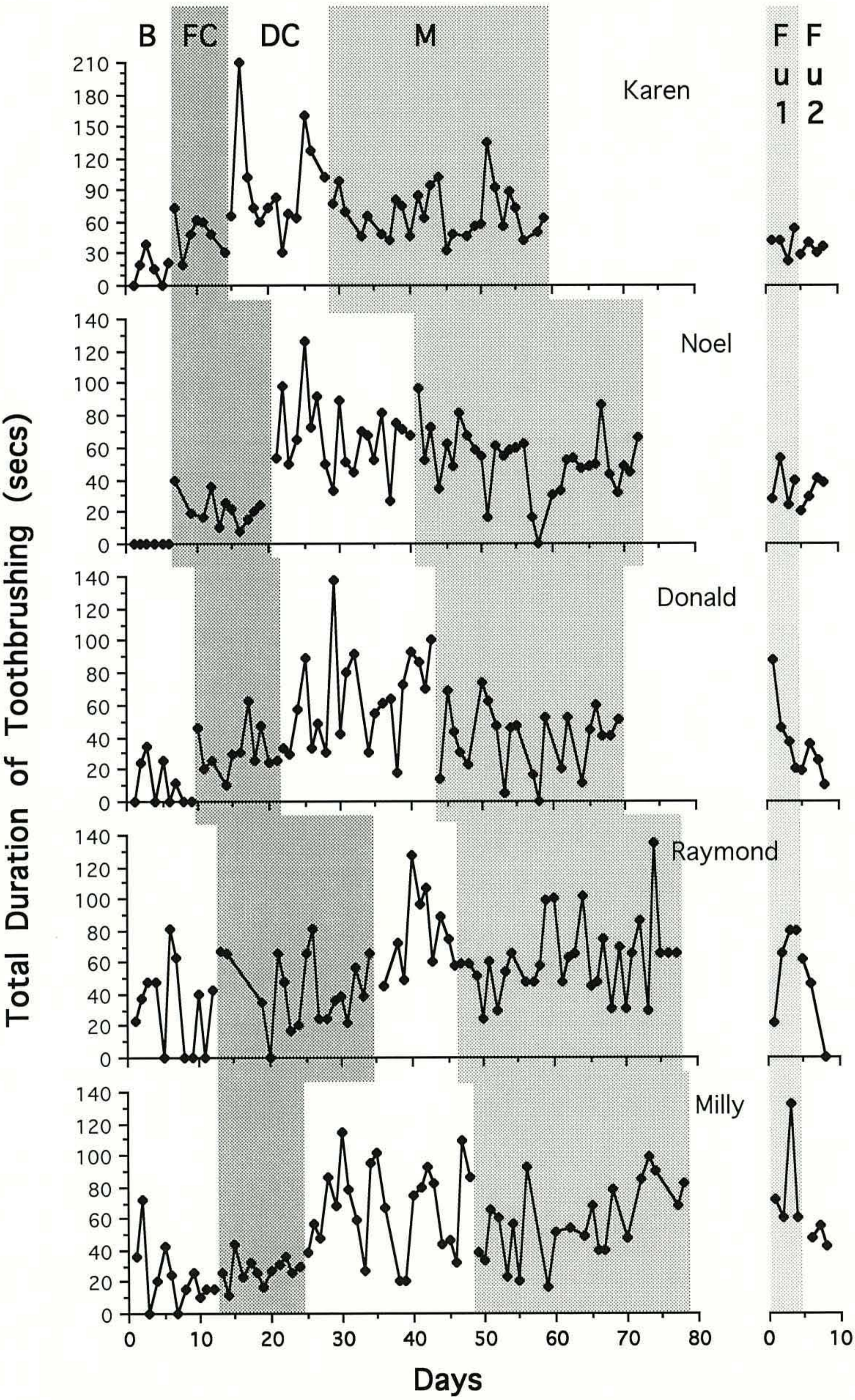
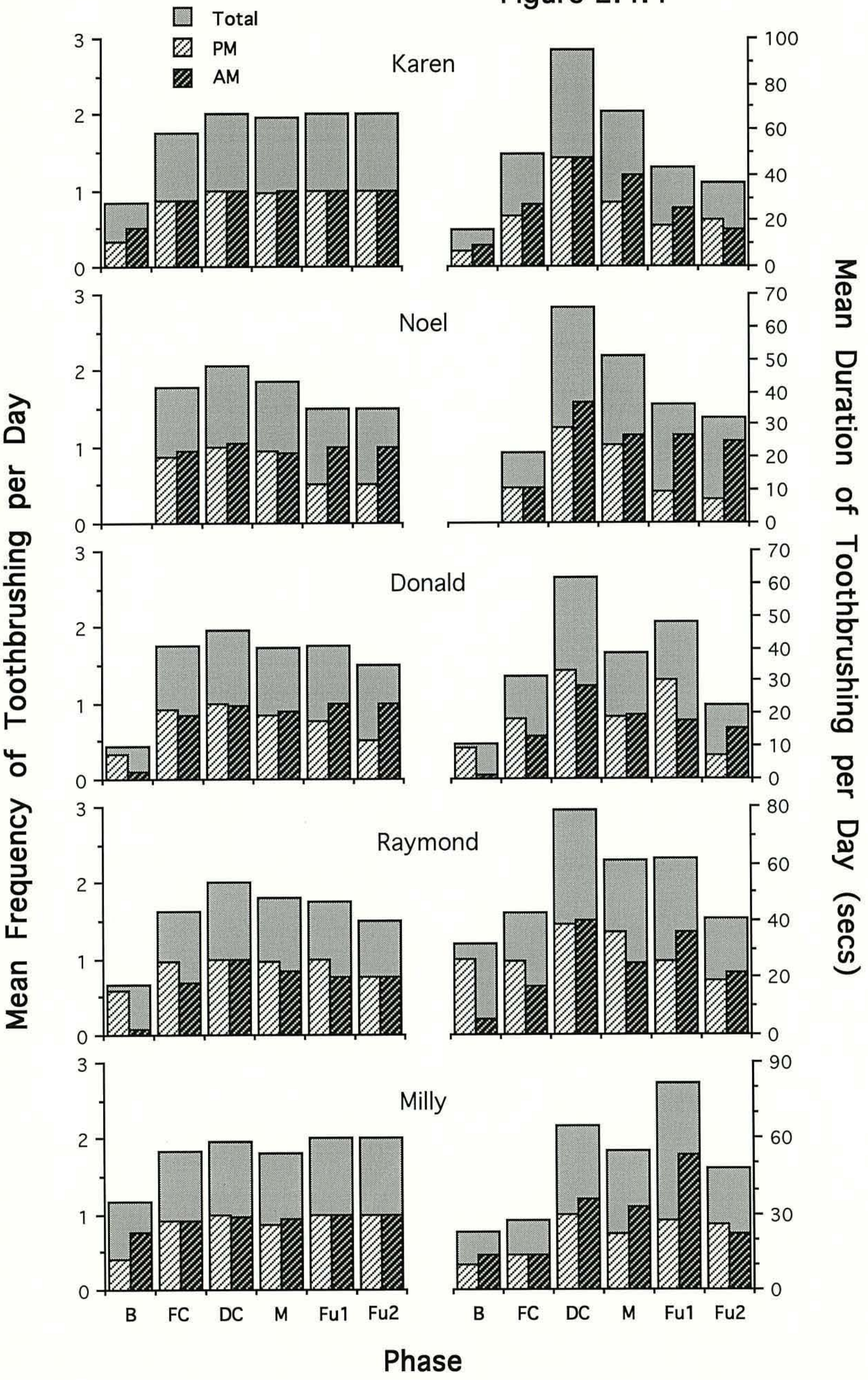

B
FC
DC
M
Fu1
Fu2
Karen
Noel
Donald
Raymond
Milly
Total Duration of Toothbrushing (secs)
Days

Figure 2.4.4

The mean frequency of toothbrushing per day (left side) and the mean total duration of brushing per day (right side) for each subject in each of the phases. The means for evening (light diagonal line shading) and morning sessions (dark diagonal line shading) in each phase are also shown. Data for the frequency graph (left side) were calculated by totalling the number of brushing events that occurred at night and in the morning, and dividing by the total number of days in the phase. Data for the duration graph were calculated by totalling each subject's known durations at night and in the morning in each phase and dividing by the total number of sessions (of known duration) in the phase.

Figure 2.4.4



Total
PM
AM
Karen
Noel
Donald
Raymond
Milly
Mean Frequency of Toothbrushing per Day
Mean Duration of Toothbrushing per Day (secs)
B
FC
DC
M
Fu1
Fu2
Phase

Table 2.4.4

Mean Total Duration Difference Scores

Experiment 2

The percentage difference between each subject's Baseline mean total duration per day and his/her mean total duration per day in all subsequent phases: Frequency Compliance Training (FC), Duration and Frequency Compliance Training (DC), Maintenance (M) and both two-month Follow-ups (Fu1 and Fu2). Percentage difference was calculated in the same way as for Experiment 1 (Table 2.2.4). Any Phase Mean value of zero was assigned a nominal value of 1 second to enable a calculation to be made.

Subjects and Sessions	Experimental Conditions				
	FC	**DC**	**M**	**Fu1**	**Fu2**
Karen					
PM	234%	636%	329%	177%	215%
AM	187%	387%	317%	166%	66%
Total	**206%**	**494%**	**322%**	**170%**	**127%**
Noel					
PM	946%	2820%	2297%	850%	625%
AM	991%	3557%	2594%	2575%	2400%
Total	**2037%**	**6477%**	**4990%**	**3525%**	**3125%**
Donald					
PM	98%	258%	106%	228%	- 21%
AM	971%	2243%	1510%	1352%	1148%
Total	**200%**	**491%**	**270%**	**360%**	**115%**
Raymond					
PM	- 4%	45%	34%	- 4%	- 30%
AM	224%	660%	381%	586%	319%
Total	**34%**	**146%**	**92%**	**93%**	**28%**
Milly					
PM	40%	205%	133%	185%	166%
AM	4%	163%	141%	298%	63%
Total	**19%**	**181%**	**138%**	**251%**	**106%**

As in Experiment 1, total duration levels dropped slightly when rewards were faded in the Maintenance condition (M). Although neither Raymond nor Donald brushed for longer on each occasion in this condition than they had done in Baseline (see Figure 2.4.2 and Table 2.4.3), like the other subjects, because of their improved frequency, they still spent much more time brushing their teeth each day (an improvement over Baseline of above 90% in all cases). The pattern of behaviour in Follow-ups (Fu1 & Fu2) relative to the other conditions was similar to that in Experiment 1.

Figure 2.4.4 and Table 2.4.4 show that the interventions affected brushing both at night and in the mornings, and these improvements (especially frequency) were well maintained at Follow-up. For three subjects, however, as in Experiment 1, improvements over Baseline tended to be better maintained in the morning than at night, possibly for the same reasons as were described in the discussion of the first experiment.

DISCUSSION

The parents in this experiment, under the supervision of the experimenter, successfully implemented a compliance training procedure designed to promote the frequency and duration of their children's toothbrushing. An instruction to *brush every part of all teeth and gums every night and every morning* with rewards delivered contingent upon the subjects brushing twice a day (Frequency Compliance Training) increased brushing frequency in all cases, but did not lead to uniform substantial increases in the subject's total durations of toothbrushing per day. The same instruction, with contingencies on both frequency and duration of toothbrushing (Duration Compliance Training) led to clear improvements in brushing durations in all cases. These improvements were well maintained when the experimenter-imposed contingencies were faded out in the Maintenance condition, and performance during the two-month Follow-ups was considerably better than in the initial Baseline phase.

2.5. GENERAL RESULTS AND DISCUSSION

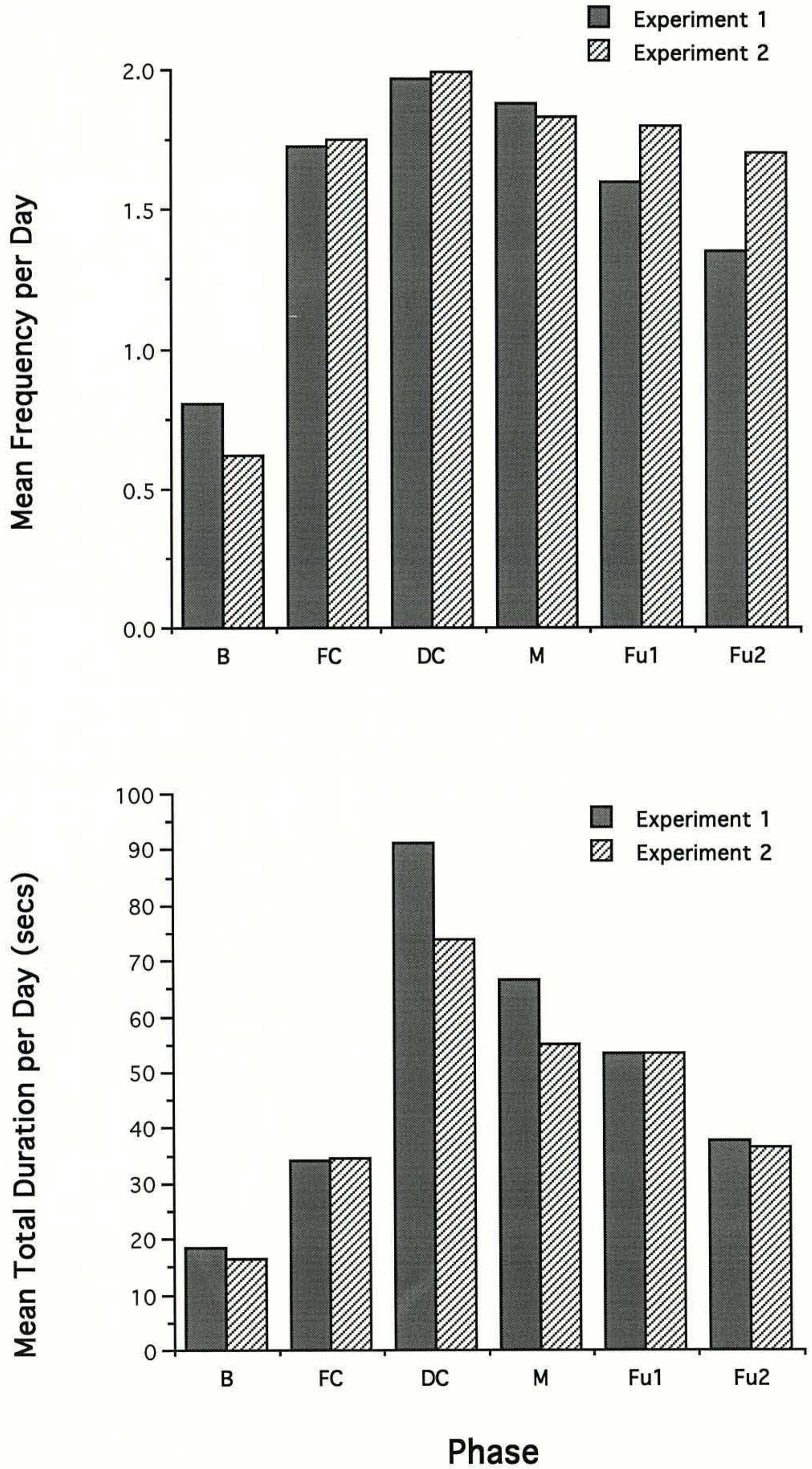
Comparing results from Experiment 1 with those from the second experiment, it can be seen that the patterns and levels of improvement are very similar for both frequency and duration of toothbrushing. The improved behaviour was maintained at very similar levels during the Maintenance and Follow-up conditions. Presented in Figure 2.5.1 is an inter-experimental comparison of data from only very few subjects. This should be treated as rough descriptive guide which may be indicative, but from which no firm conclusions can be drawn. Further large between-group studies would need to be conducted to confirm the findings. The figure shows a comparison of mean daily frequency (top) and mean total duration of toothbrushing per day (bottom) across all subjects in each phase in the two experiments.

Although the aggregated data show slightly better effects on frequency of toothbrushing with the Compliance procedure, and slightly better effects on duration with the Correspondence procedure, the results are so similar that, on the basis of these experiments, one method cannot be said to be more effective than the other. These results add to the evidence from two previous studies (Baer, Detrich & Weninger, 1988; Deacon & Konarski, 1987; Weninger & Baer, 1990), which indicate that the overt verbalization made by children in the correspondence training paradigm may not be a necessary independent variable. The present evidence adds additional weight to this argument, because the procedure ensured that subjects exposed to the Compliance condition were *never* previously exposed to a reinforcement of verbalizations condition.

Figure 2.5.1

Mean daily frequency (top) and mean total duration of toothbrushing per day (bottom) in each of six conditions in the two experiments: Baseline (B), Frequency Correspondence or Frequency Compliance Training (FC), Duration Correspondence or Duration Compliance Training (DC), Maintenance (M) and Follow-ups (Fu1 and Fu2). Data for the frequency graphs were calculated by totalling the number of occasions that all subjects brushed in each condition, and dividing this by the total number of days exposure to the condition. Data for the duration graphs were calculated by totalling the amount of time the subjects spent brushing their teeth in each condition, and dividing by the total number of days exposure to the condition.

Figure 2.5.1


Experiment 1
Experiment 2
Mean Frequency per Day
2.0
1.5
1.0
0.5
0.0
B
FC
DC
M
Fu1
Fu2
Experiment 1
Experiment 2
Mean Total Duration per Day (secs)
100
90
80
70
60
50
40
30
20
10
0
B
FC
DC
M
Fu1
Fu2
Phase

Baer, Detrich and Weninger (1988) suggest the possibility of two types of regulation, "during reinforcement of correspondence, self-regulation may occur, whereas during reinforcement of doing, responding is controlled by the antecedent cues and subsequent reinforcement provided by the experimenter" (p.355). Their data also "suggest that an antecedent verbalization regarding the target behavior is important" (p.353). In other words, instruction must be a controlling variable in both the correspondence and the compliance procedure, and given the time delays, rule-governance is implicated (see Catania, 1992; Cerruti, 1989). It has been argued in Chapter 1 that the terms 'rule-governance' and 'verbal regulation' refer to essentially the same process. If this is correct then the important question is not whether certain training methods promote self-regulation or rule-governance, but whether there is any advantage in utilizing the correspondence rather than the compliance procedure.

If the aim is to promote generalized correspondence between 'doing' and 'saying about doing', then there may indeed be good reason to employ the correspondence training method, but as suggested by Guevremont *et al* (1986a) and discussed in Chapter 1, it would be necessary to train several specific correspondences in the presence of a general correspondence rule (e.g. "It pays to do what you say."). However, if the aim is simply to alter a specific nonverbal behaviour, the evidence from Experiments 1 and 2 suggests that a compliance training procedure is as effective as correspondence training.

In general, although subjects in both of the current experiments spent more time brushing their teeth each day in the Follow-ups than in the Baseline condition, they spent much less time than they had done in the intervention phases. During training the children were told that to keep their teeth healthy and clean, they should brush every part of all of their teeth and gums every night and every morning. Although this instruction refers to the natural consequences of regular toothbrushing, the children were also told that they would receive a reward for compliance. It was apparent to the subjects that the reinforcers specified by the rule would be 'contractually' provided by the parents. In other words, reinforcement of rule following was 'socially mediated' during training in both studies, and therefore should be viewed as 'pliance' (Zettle & Hayes, 1982).

According to Zettle and Hayes (1982), rule following will occur in the absence of 'socially mediated' contingencies if the rule that is followed functions as a 'track'. "Tracking is rule-governed behavior under the control of the apparent correspondence between the rule and the way the world is arranged" (Zettle, Hayes & Rosenfarb, 1989). Whether or not an established behaviour is maintained after the removal of 'socially mediated' contingencies will depend largely on its collateral consequences (see Cerutti, 1989; Skinner, 1969). For example, compliance with parental instructions to try an unfamiliar food may be reinforced by the parents' approval, but another consequence will be the taste sensations as the food enters the mouth, and this consequence will play a part in determining whether the child continues to eat the food when the compliance contingencies are removed.

After the behaviours had been established in the current study, the experimentally imposed contingencies were faded in the maintenance condition whilst the collateral consequences of good toothbrushing were emphasized verbally by the parents. Parents were asked to highlight the health and cosmetic benefits of toothbrushing, but this attempt to promote tracking was only partially effective. One reason might be that the natural positive consequences of a single toothbrushing event are more evident after several days of not brushing than they are if the teeth are brushed regularly (i.e. the oral and olfactory sensations are more noticably different). Secondly, the negative consequences of not brushing are cumulative and not immediately evident; it takes a few days for an unbrushed tooth to become unpleasantly yellow; it takes a month or two for a cavity to develop, and it is several years before the teeth drop out. Future research should examine methods of making the consequences of toothbrushing more immediately apparent.

Effective toothbrushing is a skill that involves several complex actions. The child must perform intricate hand movements to effectively remove dental debris from all areas of the mouth. Although the children in the current study were able to perform these behaviours to the satisfaction of their parents in the Prebaseline phase, the video-recorded evidence shows that even in the Duration Correspondence training condition subjects still spent less time brushing their teeth than would be recommended by most dentists (see Thaller, Reiser & Ward, 1972), and they did not cover all areas of the dentition adequately. Increasing the duration of toothbrushing did not necessarily guarantee that more teeth surfaces were brushed, or that the extra time was distributed evenly on the areas that were brushed. The children had difficulty regulating the amount of time they spent brushing each part of their mouth. The possibility that principles of stimulus control could be utilized to improve the overall durations and locations of toothbrushing is investigated in the experiments reported in subsequent chapters.

The first experiment demonstrated that the correspondence training paradigm may be usefully employed by parents in their family home to improve the toothbrushing behaviour of their children. It showed that the correspondence effect is robust even when the instructions refer to two temporally separate contexts for behaviour, and during training there is a time delay of up to 16 hours between 'saying about doing' and the second instance of 'doing'. The second experiment has shown that another method, that does not require the subjects to 'say about doing', but provides them with adequate verbal instructions about the contingencies, alters behaviour as effectively as correspondence training. The effects of both procedures, which are dependent on antecedent stimulus cues as well as reinforcement, can be interpreted in terms of rule-governed behaviour, and the maintenance of these effects in terms of 'pliance' and 'tracking'.

CHAPTER 3.

INFORMATIVE STIMULI: THE EFFECTS OF A STIMULUS CONTROL DEVICE ON DURATIONS AND LOCATIONS OF TOOTHBRUSHING.

3.1. EXPERIMENT 3

The results of the first two experiments indicate that both "correspondence training" and "compliance training" methods can be used to improve the toothbrushing habits of young children. Both procedures included conditions in which a correspondence between an instruction and behaviour was reinforced. The only difference was that the "correspondence method" required that the subject verbalize the instruction and the "compliance method" did not. Because the "compliance method" involved fewer components, was easier for parents to conduct, and yielded similar results to the "correspondence method", we decided to adopt this method for further investigation in Experiment 3.

In both of the previous experiments training was applied first to frequency of toothbrushing. When the contingent behaviour had improved to a criterion level the contingencies were altered to maintain the frequency level, and to shape up increasing durations of toothbrushing. The first aim of Experiment 3 was to determine whether a condensed training package would be as effective as the procedures in the first two experiments. In this study the Compliance contingency was designed to increase frequency and duration of toothbrushing simultaneously.

Two important points arose from studying the video-recordings of the behaviour of subjects who participated in Experiments 1 and 2. Firstly, although the results provide evidence that the two training procedures were effective, the subjects, even during training, still brushed for less than the 120 seconds that is generally recommended by most dentists (see Thaller, Reiser & Ward, 1972). Secondly, it was noted that the children had difficulty regulating the amount of time they spent brushing each part of their mouth. Increasing the duration of toothbrushing did not necessarily guarantee that more teeth surfaces were brushed. It was possible that only the same few surfaces were being brushed, but for longer.

The second aim of Experiment 3 was to investigate the possibility of gaining further control over children's toothbrushing behaviour by incorporating a stimulus control device (the "Toothtutor") into the procedures. This device consisted of a Teddy Bear's face with open mouth, in which was depicted clearly rows of teeth, each of which could be illuminated in turn by pressing a button mounted on the side of the display. This provided a visual and temporal guide for the child, showing where to brush and for how long. The device was designed to enhance stimulus control of children's toothbrushing behaviour and to promote (i) further increases in overall brushing durations, (ii) more effective regulatation of the locations of brushing behaviour, and (iii) more systematic regulation of the amount of time spent brushing the dentition in each area of the mouth.

METHOD

PARTICIPANTS

(a) Subjects

Participating in Experiment 3 were two girls and a boy (Kathy, Melissa and Norman) who all had a younger sibling. The mean age of subjects was 6 years 0 months. See Table 3.1.1 for complete subject and sibling details.

(b) Parents

In all cases the subject's mother administered the interventions.

SETTINGS AND MATERIALS

(a) Recording

Slightly modified video equipment was used in this and subsequent experiments. The cabinets (shown in Figure 3.1.1) that were installed in the three family bathrooms differed to those used in Experiments 1 and 2 in that the microswitch in the toothbrush holder activated, not only the VCR, but also two horizontal strip lights fitted above and below the 2-way mirror. This modification was made for two reasons, first to improve the quality of the video images, and second to make it more obvious to parents when the equipment was recording. In all other respects the apparatus was the same as before.

TABLE 3.1.1

AGE OF SUBJECTS AND THEIR SIBLINGS

EXPERIMENT 3

Subject	Age at start	Number of Siblings	Age of Siblings
Kathy	5 yrs 9 mths	2	3 yrs & 4 yrs
Norman	6 yrs 0 mths	1	2 yrs
Melissa	6 yrs 2 mths	1	3 yrs

Mean age of subjects at start = 6 yrs 0 mths

Figure 3.1.1

A photograph of the modified recording apparatus as seen from the subjects' viewpoint.

(b) **Stimulus Control**

A "Toothtutor" (see Figure 3.1.2) was installed in each bathroom at a time determined by the experimental design (i.e. after Compliance Training). Each of these battery operated electronic devices is contained in plastic box (height, 190mm; width, 140mm; depth, 45mm), and on the front of the box is a colourful laminated drawing of a Teddy bear's face. The Teddy's mouth is open so that all of his twenty four teeth are visible. Above the face are three rectangular lights each with a different legend. The green light on the left illuminates the word "inside", the orange light in the middle illuminates "outside", and the red on the right illuminates "bite". All of the Teddy's teeth are Light Emitting Diodes (LEDs).

Below the face on the left side of the front of the box is a button. When this button is first depressed and released, the green "inside" light is illuminated, the Toothtutor emits an intermittent sound (like a drum beat) of a particular frequency, and three LED "tooth lights", on the top left of the Teddy's mouth, are illuminated for 5 seconds and then extinguished. Immediately, whilst the "drum beat" continues and the "inside" light stays on, the next three "tooth lights" on the top arch are illuminated and then extinguished after a further five seconds. This sequence continues until the four groups of "tooth lights" in the top arch, and then the four groups in the bottom arch, have been illuminated and extinguished in turn.

Figure 3.1.2

A photograph of the Toothtutor.

The green "inside" light remains illuminated and the drum sound continues at the same frequency until the button is depressed for the second time. The green light goes off and the orange "outside" light is illuminated. The drum sound continues with the same beat, but the tone frequency is increased. All of the "tooth lights" come on and go off in sequence as before, and when this is complete the button is depressed for a third time, the orange light goes off, the red "bite" light goes on, and the tone frequency of the drum beat is made still higher. Only the four groups of "tooth lights" at the sides of the Teddy's mouth (the molar teeth) are illuminated in this final sequence. The complete cycle is programmed to last for 120 seconds, and the Toothtutor signals the end of the cycle by playing any one of seven different popular tunes stored in its memory.

DEPENDENT VARIABLES AND RECORDING

(a) **Target Behaviours**

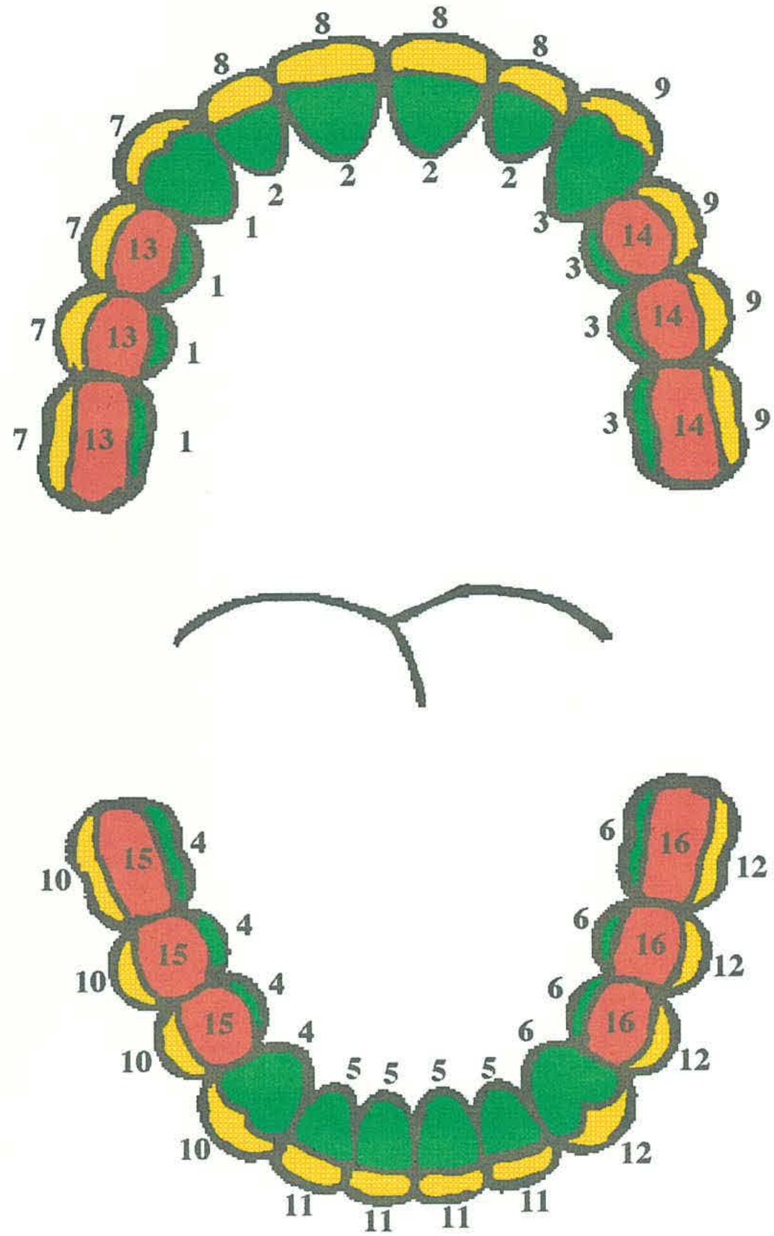
The dependent variables were: (i) toothbrushing frequency, (ii) toothbrushing duration, and (iii) the number of dentition locations brushed during each toothbrushing session. For the measurement of this latter variable the dentition was divided into 16 well-defined areas, and in each brushing session the number of these areas that were brushed by the subject were recorded. This method of recording locations of toothbrushing was devised by Rugg-Gunn and MacGregor (1978). Figure 3.1.3 is a diagram of an open mouth showing how the dentition was divided into 16 areas.

Figure 3.1.3

A diagram of an open mouth showing how the dentition was divided into 16 locations:

1. Lingual surfaces, upper dental arch, right posterior segment.
2. Lingual surfaces, upper dental arch, anterior segment.
3. Lingual surfaces, upper dental arch, left posterior segment.
4. Lingual surfaces, lower dental arch, right posterior segment.
5. Lingual surfaces, lower dental arch, anterior segment.
6. Lingual surfaces, lower dental arch, left posterior segment.
7. Buccal surfaces, upper dental arch, right posterior segment.
8. Labial surfaces, upper dental arch, anterior segment.
9. Buccal surfaces, upper dental arch, left posterior segment.
10. Buccal surfaces, lower dental arch, right posterior segment.
11. Labial surfaces, lower dental arch, anterior segment.
12. Buccal surfaces, lower dental arch, left posterior segment.
13. Occlusal surfaces, upper dental arch, right posterior segment.
14. Occlusal surfaces, upper dental arch, left posterior segment.
15. Occlusal surfaces, lower dental arch, right posterior segment.
16. Occlusal surfaces, lower dental arch, left posterior segment.

Figure 3.1.3



LOCATION

(b) **Reliability**

A second observer independently measured toothbrushing durations and number of locations brushed from 20% of the recorded toothbrushing occurrences. As in previous experiments, these reliability checks were distributed evenly across subjects and experimental conditions, and agreement for both measures was calculated using the frequency ratio method and Pearson's Product-moment correlation coefficient (see General Method).

The overall agreement for toothbrushing durations, calculated using the Frequency Ratio method, was 94.1%. Agreement for Kathy was 94.0%; for Norman, 95.4%; and Melissa, 92.8%. Pearson's Product-moment correlations between the observers' measures were: overall, 0.989; for Kathy, 0.988; Norman, 0.994; and Melissa, 0.986. These levels of agreement are similar to those in the first two experiments.

The overall agreement for toothbrushing locations, calculated using the Frequency Ratio method, was 97.1%. Agreement for Kathy was 94.1%; for Norman, 100%; and Melissa, 97.3%. Correlations between the observers' measures were: overall, 0.894; for Kathy, 0.896; Norman, 0.852; and Melissa, 0.933. Taken together, the results of these two measures indicate that there is a high degree of absolute agreement between observers' estimates of number of locations brushed, and reliable covariation between their scores.

EXPERIMENTAL DESIGN

After baselines of six days (Kathy), nine days (Norman), and twelve days (Melissa), the following intervention conditions were systematically introduced:

(1) Compliance Training

(2) Compliance Training + Toothtutor

(3) Maintenance of Compliance.

PROCEDURE

Prebaseline

The length of the prebaseline phase was increased to seven days in this and all subsequent experiments. As well as allowing the children to become accustomed to the mirror and to get over any novelty effects, this time was used to establish the subjects' ability to independently perform all the constituent behaviours of toothbrushing (see Section 2.2 - General Method).

Compliance Training

After baseline the subjects were exposed to a condition similar to the Duration Compliance intervention in Experiment 2. The only difference was that, as this condition was not now preceded by a Frequency Compliance condition, procedures were implemented to increase both frequency and durations of toothbrushing simultaneously.

Compliance Training + Toothtutor

On the first afternoon of this condition, the parent showed the device to the child and demonstrated its use. The parents were asked to say:

A *'This is Teddy Toothtutor, and he is going to help you to brush every part of all of your teeth and gums. If you do as he shows you every night and every morning, your teeth will always be sparkling clean. Now, on the top, here, are three lights. When the* ***green light*** *that says "inside" is on, you have to brush the* ***inside parts*** *of your teeth.* [Parent shows the child the inside surfaces of her teeth] *Close your mouth, and feel the insides of your teeth with your tongue. When the* ***orange light*** *that says "outside" is on, you should brush the* ***outside parts****.* [Parent shows the child] *If you open your mouth, you can feel the outsides of your teeth with your tongue. Try it.* [Child feels the outside surfaces of teeth] *When the* ***red light*** *that says "bite" is on, you should brush the* ***biting parts*** *of your back teeth.* [Parent demonstrates] *These are the flat parts of your back teeth that have bumpy edges. Can you feel them?*

B *'Okay, now look at Teddy's teeth, all of them have got lights in. These lights show you which teeth to brush, and for how long. Let me show you.* [Parents demonstrate the whole sequence brushing their own teeth] *Now you try.* [Parents allow the child to attempt to follow the whole sequence, helping if necessary] *Good, well done! Now that is how you should brush your teeth at night before bed and in the morning after breakfast. Can you feel with your tongue how clean are all the parts of your teeth?*

C *'Now, to get a gold star and a present, you must spend a long time carefully brushing every part of all your teeth and gums, every night and every morning. I want you to brush better than you have ever done before, so use Teddy today to help you.'*

The contingencies, as in the previous condition, were designed to increase durations of toothbrushing.

Maintenance of Compliance

The maintenance procedure was like that in Experiment 2 except that the Toothtutor remained present and the children were instructed to continue to use it.

Follow-up

The Toothtutors were left in the bathrooms and were maintained in working order during the eight weeks between the end of the Maintenance condition and the first Follow-up phase. In this condition the children's toothbrushing performance was monitored for nine days with the Tutors still in place. At the end of this phase the Tutors were removed, and two weeks later, in the second Follow-up phase, data were collected for a further nine days under Baseline conditions. Parents were asked not to prompt their children to brush their teeth at any time during the two Follow-up conditions.

RESULTS

Frequency of Toothbrushing

Figure 3.1.4 and Table 3.1.2 show that only one subject (Norman) did not brush frequently during Baseline (B). Norman brushed twice a day every day when the Compliance Training contingency was introduced (C), and he brushed three times a day for the first two days after the the introduction of the Toothtutor (CT). During Maintenance (M) and in the first Follow-up condition (Fu1) his frequency fluctuated between once and twice a day. Norman brushed slightly less often after the Toothtutor had been removed in the second Follow-up (Fu2). Kathy brushed twice a day every day except on 7 occasions in 32 days of Maintenance, and on one occasion in each of the Follow-up conditions.

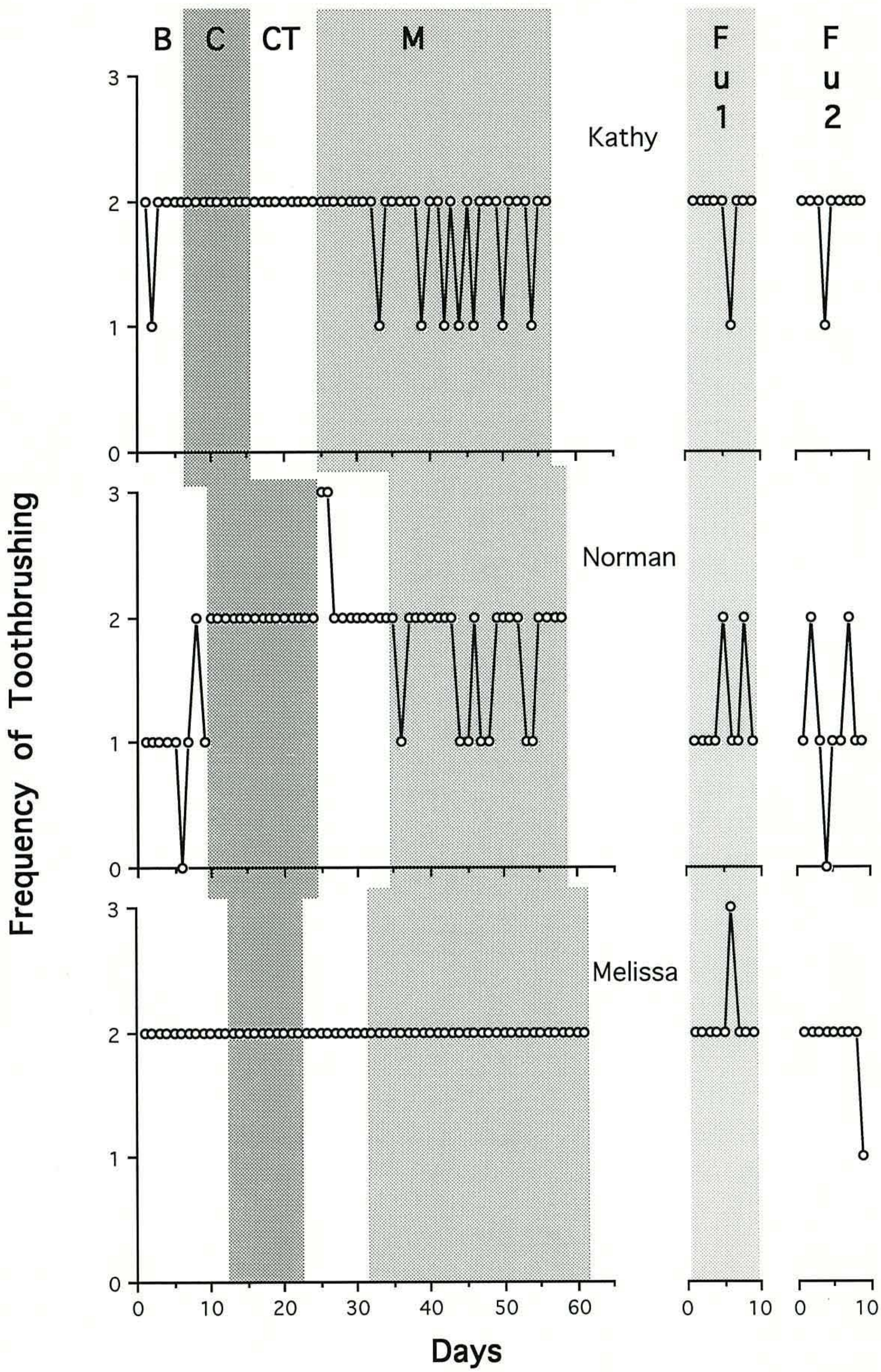
Duration of Toothbrushing per Occasion

In Baseline (B), although Norman brushed much less frequently than Melissa, it can be seen from Figure 3.1.5 and Table 3.1.3 that they spent similar amounts of time brushing their teeth on the occasions that they brushed. Although Kathy tended to brush for longer than the other subjects during Baseline, clear improvements in mean duration per occasion can be seen for all subjects when the interventions were introduced.

Figure 3.1.4

Frequency of toothbrushing per day for each subject during each experimental phase: Baseline (B), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Figure 3.1.4



B
C
CT
M
Fu1
Fu2
Kathy
Norman
Melissa
Frequency of Toothbrushing
Days
0
1
2
3
0
10
20
30
40
50
60

TABLE 3.1.2

Mean Frequency of Toothbrushing

Experiment 3

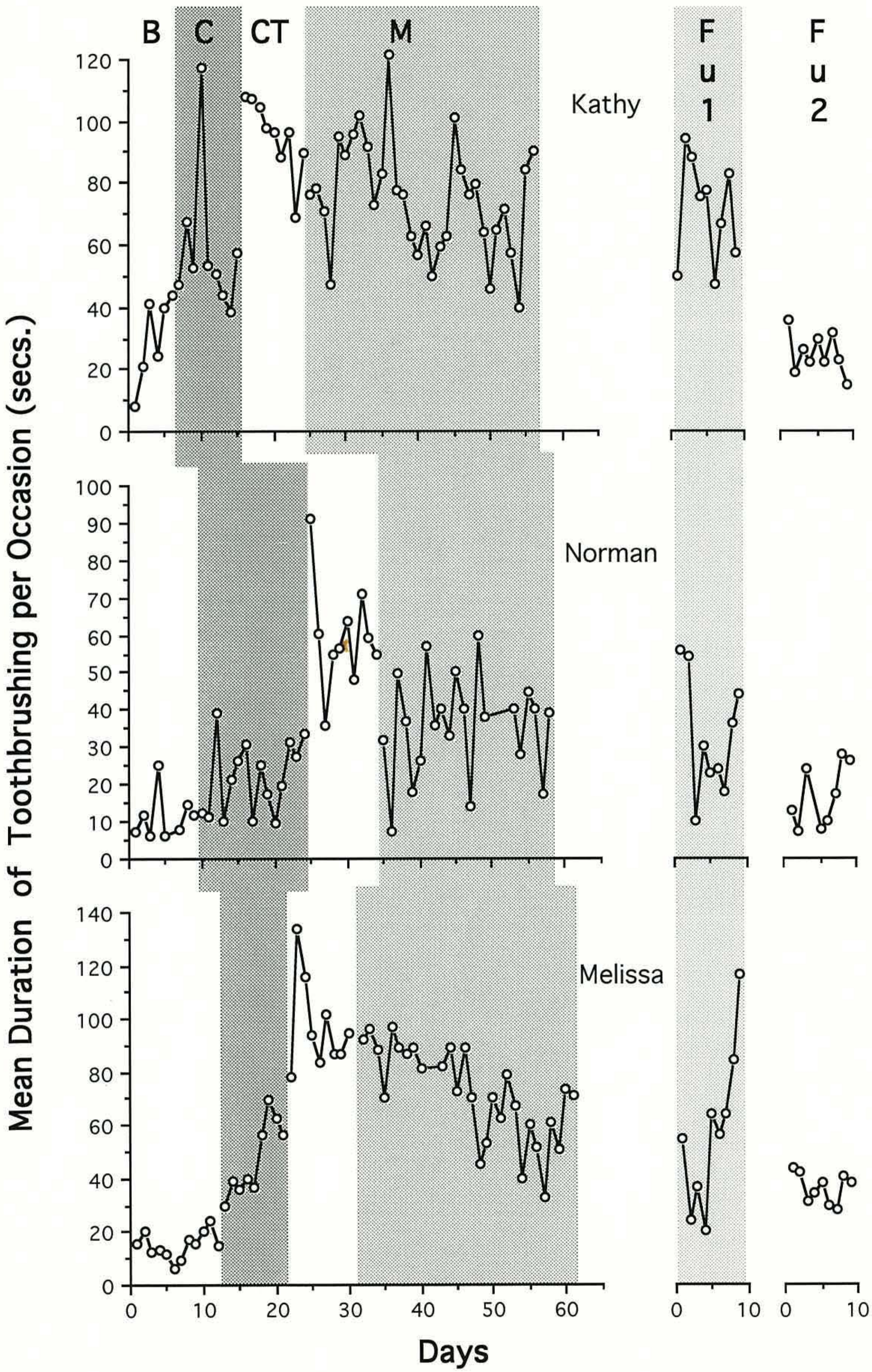
Each subject's mean frequency of toothbrushing per day, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions					
	B	**C**	**CT**	**M**	**Fu1**	**Fu2**
Kathy						
Mean	1.83	2.00	2.00	1.78	1.89	1.89
Std D	0.41	0	0	0.42	0.33	0.33
N	6	9	9	32	9	9
Range	1 - 2	2 - 2	2 - 2	1 - 2	1 - 2	1 - 2
Norman						
Mean	1.00	2.00	2.20	1.71	1.22	1.11
Std D	0.50	0	0.42	0.46	0.44	0.60
N	9	15	10	24	9	9
Range	0 - 2	2 - 2	2 - 3	1 - 2	1 - 2	0 - 2
Melissa						
Mean	2.00	2.00	2.00	2.00	2.11	1.89
Std D	0	0	0	0	0.33	0.33
N	12	10	9	30	9	9
Range	2 - 2	2 - 2	2 - 2	2 - 2	2 - 3	1 - 2
Overall Mean	1.61	2.00	2.07	1.83	1.74	1.63

Figure 3.1.5

Mean duration of toothbrushing per occasion per day for each subject during Baseline (B), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). These data were calculated by totalling all the recorded durations each day, and dividing this sum by the daily frequency.

Figure 3.1.5



B
C
CT
M
F u 1
F u 2
Kathy
Norman
Melissa
Mean Duration of Toothbrushing per Occasion (secs.)
Days
0
10
20
30
40
50
60

TABLE 3.1.3

Mean Duration per Occasion

Experiment 3

Each subject's mean duration per occasion , the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions					
	B	**C**	**CT**	**M**	**Fu1**	**Fu2**
Kathy						
Mean	29.75	58.67	95.33	74.84	71.17	25.00
Std D	14.23	23.55	12.13	18.29	16.88	6.60
N	6	9	9	32	9	9
Min	8.00	38.50	69.00	40.00	47.00	15.00
Max	44.00	117.50	108.00	121.50	94.50	36.00
Norman						
Mean	11.31	21.70	59.57	35.62	32.83	16.69
Std D	6.38	9.76	14.52	13.64	16.00	8.42
N	8	15	10	21	9	8
Min	6.00	9.50	36.00	7.00	10.00	7.00
Max	25.00	39.00	91.33	60.00	56.00	28.00
Melissa						
Mean	15.21	50.45	99.75	71.95	57.91	36.33
Std D	5.01	16.33	17.08	17.68	10.05	5.55
N	12	10	8	28	9	9
Min	6.50	30.00	84.00	32.50	20.00	28.50
Max	24.50	78.00	133.50	97.00	116.50	43.50
Overall Mean	18.76	43.61	84.88	60.80	53.97	26.01

Kathy and Norman both doubled their average duration of toothbrushing per occasion after exposure to the Compliance Training intervention (C), whilst Melissa's average in this condition was more than three times the level in Baseline. The introduction of the Toothtutor had a profound effect on durations per occasion in all cases. In the Compliance Training + Toothtutor phase (CT), Melissa and Kathy (whose mean per occasion was more than 88 seconds on all but one day) both increased their average duration per occasion to over six and a half times their Baseline levels. Norman's average duration per occasion was almost 60 seconds compared to a Baseline mean of only 11 seconds. All three subjects brushed well in the Maintenance and first Follow-up conditions, but only Melissa's duration of brushing per occasion was considerably higher in the second Follow-up (after removal of the Toothtutor) than in Baseline.

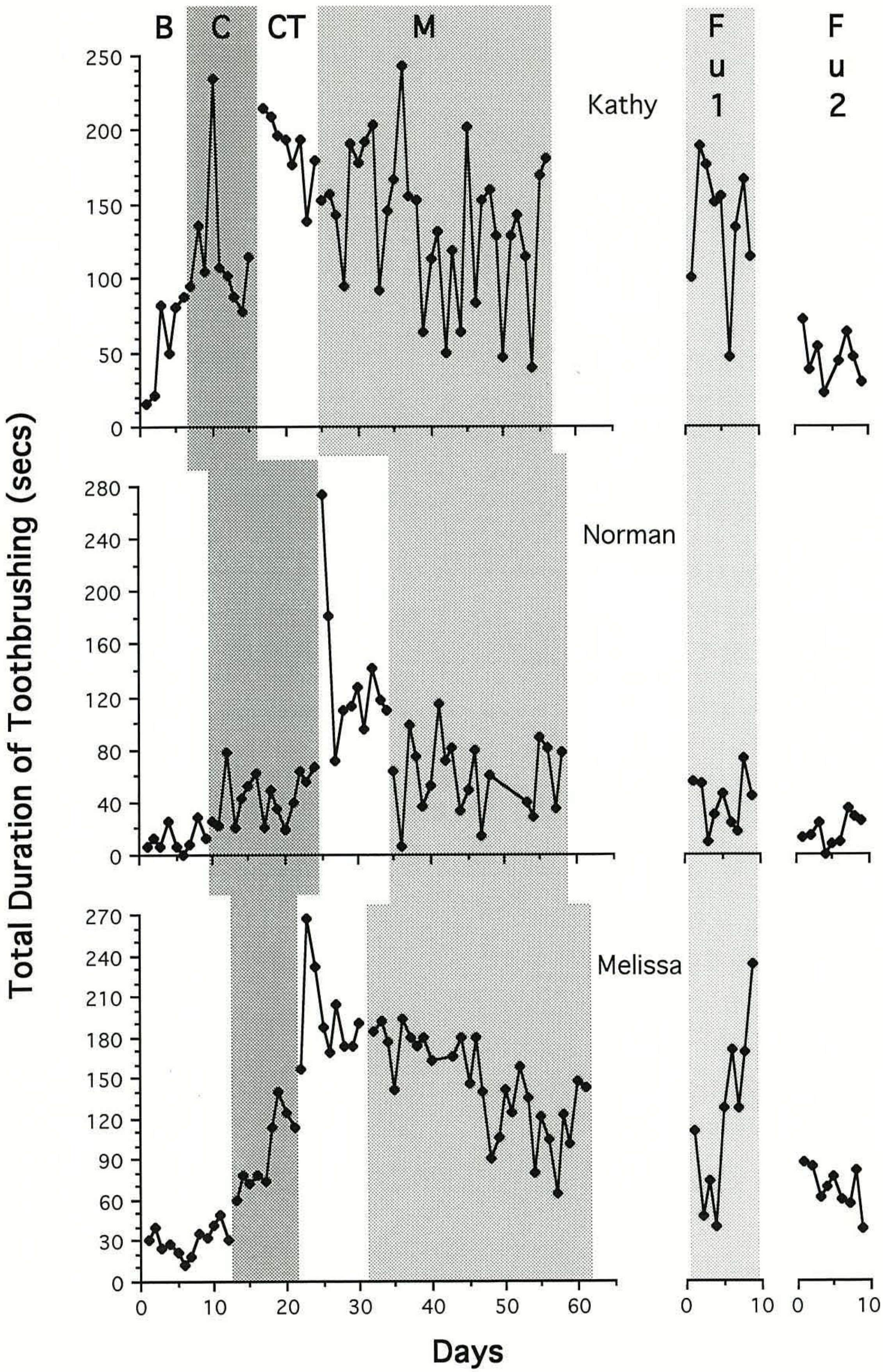
Total Duration of Toothbrushing

Figure 3.1.6 represents each subject's total duration of toothbrushing each day, which is a combination of the frequency of brushing per day and the duration of each brushing event. Figure 3.1.7 depicts an overall summary of each subject's data for each phase in Experiment 3 (on the left, mean frequency of toothbrushing per day, and on the right, the mean total duration of brushing per day). The data presented in Table 3.1.4 are the difference scores between the Baseline mean total duration per day and the mean total duration per day in each of the subsequent phases, expressed as a percentage of the Baseline duration.

Figure 3.1.6

Total duration of toothbrushing per day for each of the subjects during Baseline (B), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). Data for this figure were calculated by totalling known durations of all toothbrushing events that occurred on each day.

Figure 3.1.6



B
C
CT
M
F u 1
F u 2
Kathy
Norman
Melissa
Total Duration of Toothbrushing (secs)
Days
0
10
20
30
40
50
60
250
200
150
100
50
280
240
160
120
80
40
270
210
180
90

Figure 3.1.7

The mean frequency of toothbrushing per day (left side) and the mean total duration of brushing per day (right side) for each subject in each of the phases. The means for evening (light diagonal line shading) and morning sessions (dark diagonal line shading) in each phase are also shown. Data for the frequency graph (left side) were calculated by totalling the number of brushing events that occurred at night and in the morning, and dividing by the total number of days in the phase. Data for the duration graph were calculated by totalling each subject's known durations at night and in the morning in each phase and dividing by the total number of sessions (of known duration) in the phase.

Figure 3.1.7

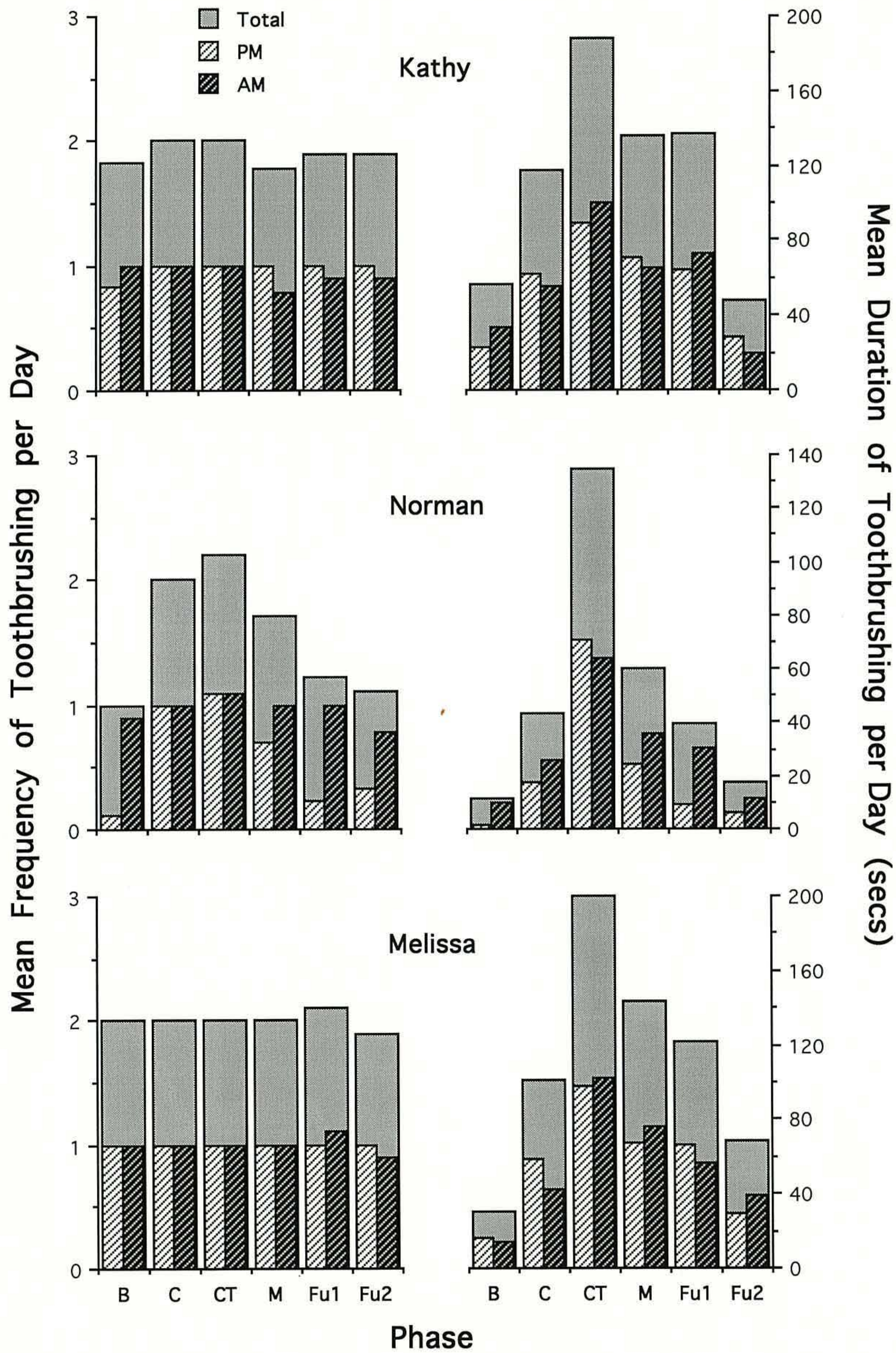

Total
PM
AM
Kathy
Norman
Melissa
Mean Frequency of Toothbrushing per Day
Mean Duration of Toothbrushing per Day (secs)
B
C
CT
M
Fu1
Fu2
Phase

Table 3.1.4

Mean Total Duration Difference Scores

Experiment 3

The percentage difference between each subject's Baseline mean total duration per day and his/her mean total duration per day in all subsequent phases: Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Sessions	Experimental Conditions				
	C	**CT**	**M**	**Fu1**	**Fu2**
Kathy					
PM	171%	289%	209%	180%	22%
AM	68%	201%	97%	121%	- 41%
Total	**110%**	**237%**	**143%**	**145%**	**- 16%**
Norman					
PM	1109%	4781%	1598%	531%	323%
AM	154%	524%	248%	197%	12%
Total	**272%**	**1051%**	**415%**	**238%**	**51%**
Melissa					
PM	262%	502%	320%	307%	80%
AM	199%	621%	437%	298%	178%
Total	**233%**	**558%**	**374%**	**303%**	**126%**
Overall Mean	**167%**	**435%**	**247%**	**205%**	**36%**

It can be seen from Figure 3.1.6 that Kathy spent more than 85 seconds brushing her teeth on only one day during Baseline (Day 6). Her total duration per day was more than 85 seconds every day after the introduction of the Compliance contingency (C), and more than 138 seconds every day during the next condition (CT) when the Toothtutor was introduced. She brushed for more than 85 seconds a day on all but 5 occasions during the 32 days of exposure to the Maintenance condition, and on all but one occasion in the nine days of the first Follow-up (Fu1). Her mean total duration per day in this condition was 145% higher than the Baseline level. After the removal of the Tutor, in the second Follow-up (Fu2), Kathy spent less time brushing her teeth each day than she had done in Baseline.

Norman's total durations per day were generally lower than the other subjects', but because the interventions increased his frequency of toothbrushing as well as his durations per occasion, his improvements over Baseline were most impressive. He brushed for a total of 274 seconds on the first day of the Compliance Training + Toothtutor condition, and his mean total duration for this phase (134.3 secs.) was 1051% higher than in Baseline. Although Norman's frequency of toothbrushing had reduced to close to his Baseline level in the two Follow-up conditions, he still spent 238% more time brushing his teeth in Follow-up 1, and 51% more time in Follow-up 2.

Although Melissa brushed twice a day almost every day, clear intervention and maintenance effects can be seen in her data. Melissa's mean total duration per day was three times the Baseline level in the Compliance Training condition, six and a half times the Baseline level after the introduction of the Toothtutor, four times the Baseline level in the first Follow-up, and even after the Tutor had been removed (in Follow-up 2) it was still more than twice the Baseline level.

Norman was the only subject who did not brush consistently twice a day on most days, and like the majority of subjects in Experiments 1 and 2, he brushed less often at night than in the morning during the Follow-ups when his parents were not reminding him.

Locations of Toothbrushing

Figure 3.1.8 and Table 3.1.5 show that, as was the case with durations, Kathy's behaviour in Baseline was noticeably better than that of the other two subjects. The number of locations brushed by all three children increased, along with duration, when the compliance contingency was introduced (C). Kathy achieved a perfect score of 16 locations both at night and in the morning on 3 separate days after the introduction of the Toothtutor, and she never brushed fewer than 12 locations on any occasion in this condition (CT). Her performance remained high and stable throughout the Maintenance condition (M) and the first two-month Follow-up (Fu1), and even though her mean duration had dropped to below its Baseline level in the second Follow-up (Fu2), she brushed on average about 30% more locations per occasion than she did in Baseline.

Figure 3.1.8

Mean number of locations brushed per occasion per day for each subject during Baseline (B), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). These data were calculated by adding together the number of locations brushed on each occasion each day, and dividing this sum by the frequency. Missing data points indicate that on that day either: (i) the subject did not brush, or (ii) it was not possible to record an accurate number of locations for any of the toothbrushing events, because, for example, there was not enough light in the bathroom, the subject brushed off camera, or the equipment failed to record.

Figure 3.1.8

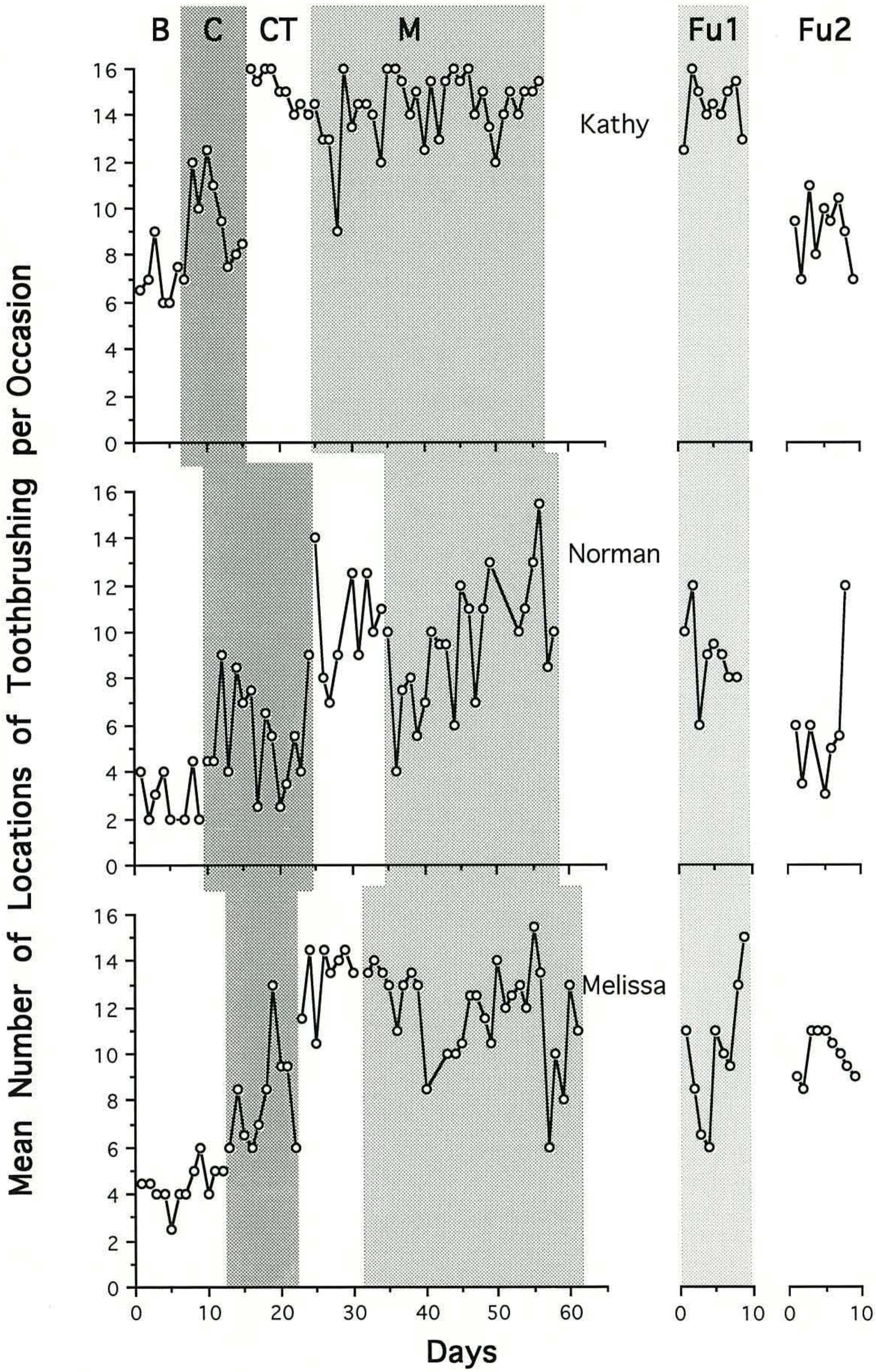

B
C
CT
M
Fu1
Fu2
Kathy
Norman
Melissa
Mean Number of Locations of Toothbrushing per Occasion
Days
0
2
4
6
8
10
12
14
16
0
10
20
30
40
50
60
0
10
0
10

TABLE 3.1.5

Mean Number of Locations Brushed per Occasion

Experiment 3

Each subject's mean number of locations brushed per occasion, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions					
	B	**C**	**CT**	**M**	**Fu1**	**Fu2**
Kathy						
Mean	7.00	9.56	15.11	14.30	14.39	9.06
Std D	1.14	1.98	0.821	1.53	1.14	1.45
N	6	9	9	32	9	7
Min	6.00	7.00	14.00	9.00	12.50	7.00
Max	9.00	12.50	16.00	16.00	16.00	11.00
Norman						
Mean	2.94	5.60	10.33	9.48	8.94	5.86
Std D	1.08	2.22	2.33	2.76	1.74	2.95
N	8	15	9	21	8	7
Min	2.00	2.50	7.00	4.00	6.00	3.00
Max	4.50	9.00	14.00	15.50	12.00	12.00
Melissa						
Mean	4.38	8.05	13.31	11.82	10.06	9.94
Std D	0.86	2.24	1.51	2.08	2.89	0.98
N	12	10	8	28	9	9
Min	2.50	6.00	10.50	6.00	6.00	8.50
Max	6.00	13.00	14.50	15.50	15.00	11.00
Overall Mean	4.77	7.74	12.92	11.87	11.13	8.29

Norman and Melissa doubled their mean number of locations brushed per occasion when exposed to the Compliance Training intervention. They tripled the Baseline level after the introduction of the Tutor, and continued to brush a high proportion of tooth surfaces throughout the Maintenance condition and the first Follow-up. Although Norman tended to brush fewer locations in the second Follow-up, his mean was still well above the Baseline level. As with duration, maintenance of effects after the removal of the Toothtutor was most impressive in the case of Melissa, whose lowest daily mean was 8.5 locations in the final condition, compared with her highest mean of 6 locations in Baseline.

DISCUSSION

This experiment investigated a number of questions raised by the results of the first two studies. First, it has shown that a condensed version of the Compliance Training procedure, designed to increase frequency and duration of toothbrushing simultaneously, can be used to promote substantial improvements in children's toothbrushing. A major unplanned difference between this experiment and the first two was that in Baseline, before exposure to the interventions, two of the children in Experiment 3, unlike any of the subjects in Experiments 1 and 2, brushed twice a day on most days and spent an average of more than 40 seconds a day brushing their teeth. The brushing behaviour of these children, as well as that of a third subject, who's frequency and duration of toothbrushing was low in

Baseline, was much improved after exposure to the Compliance Training procedure. Thus, the current experiment has shown that the procedure effectively promotes improvements even with children who already brush frequently.

Another question raised after Experiments 1 and 2 was whether the instruction to *brush every part of all teeth and gums every night and every morning,* with rewards delivered contingent upon the subjects brushing twice a day and increasing their duration of toothbrushing, would lead also to increases in the number of locations of the dentition that they brushed. The answer, at least for the three children in Experiment 3, is that the procedure does lead to increases in the number of locations brushed, but that without the further intervention of the Toothtutor the children tended to brush only about half of the sixteen designated areas of a full set of teeth.

One main aim of Experiment 3 was to investigate the effects on children's toothbrushing of incorporating a stimulus control device (the "Toothtutor") into the Compliance Training procedure. The results show that, although the children increased their total duration of toothbrushing and the number of locations brushed after exposure to the Compliance Training contingencies, the introduction of the Toothtutor promoted (i) further large increases in the amount of time children spent brushing their teeth, and (ii) more effective regulation of the number of locations brushed on each occasion.

There is evidence for a novelty effect on durations in the data of all three subjects. The children all brushed for longer at the beginning of the Compliance Training + Toothtutor condition than at the end. A slight downward trend can also be seen throughout the Maintenance condition. These trends do not appear in the location data. In fact there is generally a slight trend in the opposite direction. It appears that perhaps with continued exposure to the Toothtutor, the children learn to cover more locations of the dentition, but require less time to do it. In other words, it may be that they learn to brush their teeth more efficiently.

The Toothtutors were left in the bathrooms for two months after the end of the Maintenance condition and throughout the first Follow-up condition. The performance of all three subjects was considerably better in this first Follow-up condition than in Baseline (minimum difference score for duration = 145%). This result indicates that the stimulus control effects of the Toothtutor remained operative for up to six weeks after the withdrawal of the experimentally imposed contingencies. Duration levels were much lower in the second Follow-up (two weeks after the removal of the Toothtutor) than in the first, indicating that higher durations were largely dependent on the presence of the Toothtutor. However, the number of locations brushed per occasion did not decline to the same extent (two subjects brushed about twice as many locations per occasion in Follow-up 2 as in Baseline), indicating that during Follow-up the children depended on the Toothtutor more for an indication of duration of brushing events than for the locations of their brushing behaviour.

3.2 EXPERIMENT 4

Experiment 3 showed that, when incorporated into the Compliance Training procedure, the Toothtutor had a major effect on the children's tooothbrushing behaviour, but in that study the Toothtutor was introduced after Compliance Training. Experiment 4 was conducted to examine whether the Toothtutor alone would be similarly effective, that is, if it were intoduced to children without the exposure to a Compliance Training contingency. In Experiment 3, following Baseline, the subjects were first exposed to the Compliance Training condition before the Toothtutor was introduced. In Experiment 4 the Toothtutor was introduced first, and the children were instructed to use it, but no Compliance contingency was imposed until the next phase. In other words, in Experiment 3 the order of conditions was Baseline, Compliance Training, Compliance Training + Toothtutor, and in Experiment 4 it was Baseline, Toothtutor, Compliance Training + Toothtutor.

METHOD

PARTICIPANTS

(a) **Subjects**

Two boys and a girl participated as subjects (Martin, Craig, and Carys). See Table 3.2.1 for complete subject and sibling details.

TABLE 3.2.1

AGE OF SUBJECTS AND THEIR SIBLINGS

EXPERIMENT 4

Subject	Age at start	Number of Siblings	Age of Siblings
Martin	6 yrs 3 mths	1	18 yrs
Craig	5 yrs 6 mths	1	2 yrs
Carys	6 yrs 0 mths	1	3 yrs

Mean age of subjects = 5 yrs 11 mths

(b) **Parents**

Martin's father administered the interventions. In the other two families this role was assumed primarily by the subjects' mothers, but also occasionally by their fathers when their mothers could not be present.

DEPENDENT VARIABLES AND RECORDING

(a) **Target Behaviours**

As in Experiment 3 the dependent variables were: (i) toothbrushing frequency, (ii) toothbrushing duration, and (iii) the number of dentition locations brushed during each toothbrushing session.

(b) **Reliability**

The overall agreement for toothbrushing durations, calculated using the Frequency Ratio method, was 97.6%. Agreement for Martin was 97.3%; for Craig, 96.6%; and Carys, 98.9%. Correlations (Pearson's Product-moment) between the observers' measures were: overall, 0.988; for Martin, 0.986; Craig, 0.989; and Carys, 0.989. The Frequency Ratio agreement for locations was 97.6% overall; for Martin it was 97.3%; for Craig, 96.6%; and Carys, 98.9%. Correlations were: overall, 0.919; for Martin, 0.901; Craig, 0.916; and Carys, 0.940

EXPERIMENTAL DESIGN

After baselines of six days, nine days and twelve days the three subjects in Experiment 4 were exposed to the following intervention conditions:

(1) Toothtutor

(2) Compliance Training + Toothtutor

(3) Maintenance of Compliance.

PROCEDURE

Toothtutor

Immediately after baseline the Toothtutor was introduced and the subjects were told how to use it. They were given the same instructions as the subjects in the previous experiment (see Experiment 3 Procedure section, Compliance Training + Toothtutor instructions, paragraphs A and B), but no contingency was imposed (paragraph C omitted). Behaviour was recorded for nine days in this condition.

Compliance Training + Toothtutor

The Compliance Training contingencies were introduced with the Toothtutor still in place. On the first day the parents gave the Compliance Training instructions with respect to both frequency and duration. They reminded the subjects about the use of the Toothtutor, and instructed them to use it to guide their behaviour. The procedure on all following days in this condition was the same as that in Experiment 3. The **Maintenance** and **Follow-up** conditions were also the same.

Results

Frequency of Toothbrushing

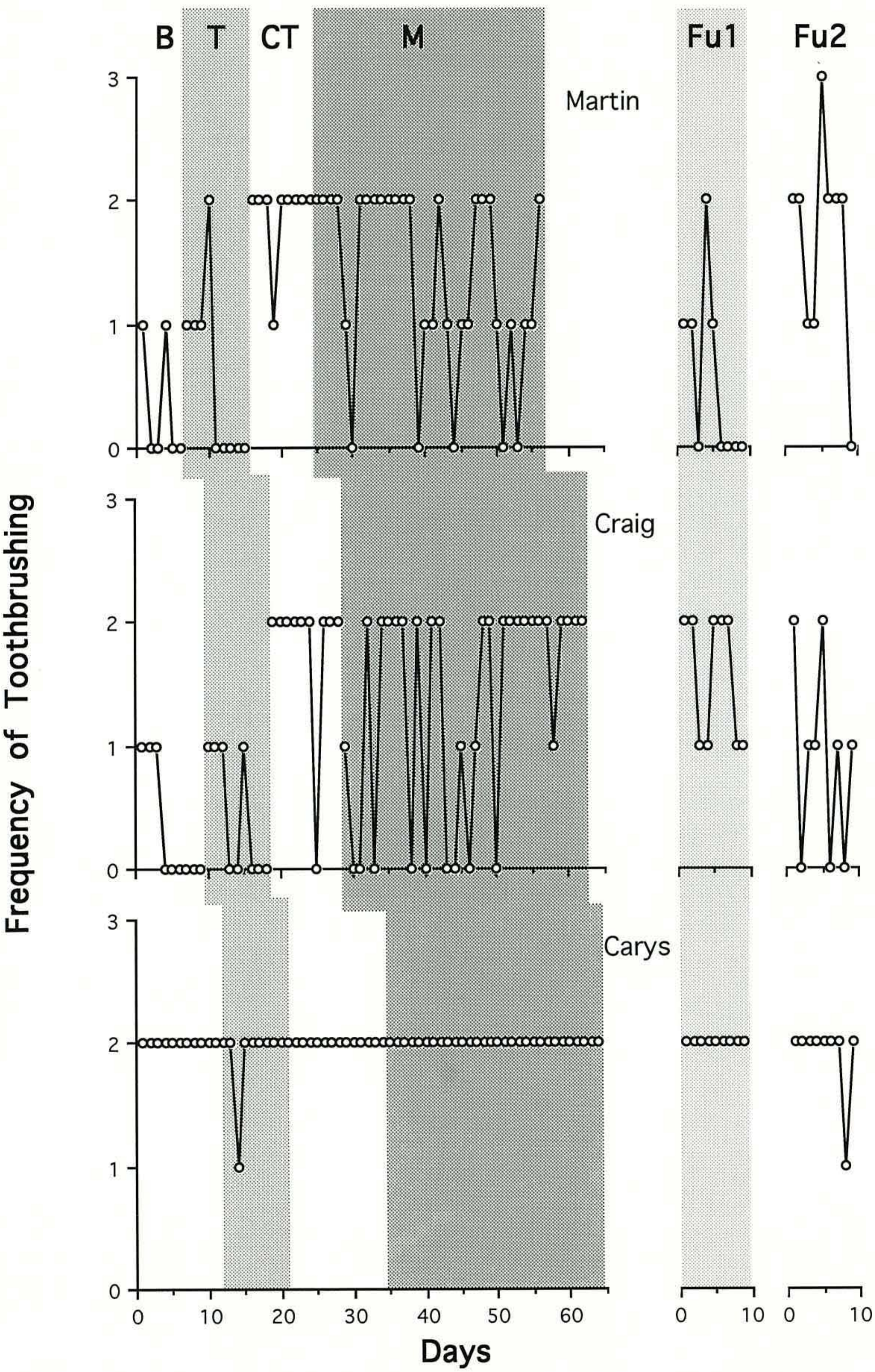
It can be seen from Figure 3.2.1 and Table 3.2.2 that Carys brushed twice a day on every day of recording except two. The first of these (Day 14) was special occasion, because it was the day when her mother returned home after a short stay in hospital, and the evening routine was disrupted. The other two subjects (Martin and Craig) brushed less frequently. Martin brushed only twice in six days during Baseline (B), once on the first day and once on the fourth. Craig brushed once a day for the first three days and then not at all. Both boys increased their frequency of toothbrushing after the introduction of the Toothtutor (T), but they stopped brushing again after the first few days of this condition.

Both Martin and Craig brushed twice a day on all but one day in the next condition when the Compliance Training contingencies were introduced (CT). The one occasion when Martin brushed only once was not because he forgot, but because he was prevented from brushing by his Mother, who thought that he had brushed earlier and that he was using toothbrushing as a reason for delaying his bedtime. The two boys brushed less frequently in the Maintenance condition (M), but on average they both brushed more than four times as frequently as they had done in Baseline. Both boys frequency of Toothbrushing was reduced in the two-month Follow-ups (Fu1 and Fu2), but they still brushed more frequently than they had done in Baseline.

Figure 3.2.1

Frequency of toothbrushing per day for each subject during each experimental phase: Baseline (B), Toothtutor (T), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Figure 3.2.1



B
T
CT
M
Fu1
Fu2
Martin
Craig
Carys
Frequency of Toothbrushing
Days
0
1
2
3
0
10
20
30
40
50
60

TABLE 3.2.2

Mean Frequency of Toothbrushing

Experiment 4

Each subject's frequency of toothbrushing per day, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Toothtutor (T), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions					
	B	**T**	**CT**	**M**	**Fu1**	**Fu2**
Martin						
Mean	0.33	0.56	1.89	1.38	0.56	1.67
Std D	0.52	0.73	0.33	0.75	0.73	0.87
N	6	9	9	32	9	9
Range	0 - 1	0 - 2	1 - 2	0 - 2	0 - 2	0 - 3
Craig						
Mean	0.33	0.44	1.80	1.35	1.56	0.89
Std D	0.50	0.53	0.63	0.88	0.53	0.78
N	9	9	10	34	9	9
Range	0 - 2	0 - 1	0 - 2	0 - 2	1 - 2	0 - 2
Carys						
Mean	2.00	1.89	2.00	2.00	2.00	1.89
Std D	0	0.33	0	0	0	0.33
N	12	9	12	31	9	9
Range	2 - 2	1 - 2	2 - 2	2 - 2	2 - 2	1 - 2
Overall Mean	0.89	0.96	1.90	1.58	1.37	1.48

Duration of Toothbrushing per Occasion

Figure 3.2.2 represents each subject's daily mean duration of toothbrushing per occasion irrespective of frequency, and Table 3.2.3 is a summary of this data in each condition. All the subjects clearly spent more time brushing their teeth when the Toothtutor was present than when it was not, and Martin's and Craig's durations per occasion were exceptionally stable in the four conditions when they were able to make use of the device (T, CT, M and Fu1). Although Carys' behaviour was less stable, the increase in duration levels over Baseline is no less evident.

Total Duration of Toothbrushing

Figure 3.2.3 represents each subject's total duration of toothbrushing each day, Figure 3.2.4 depicts an overall summary of each subject's data for each phase in Experiment 4, and the data presented in Table 3.2.4 are the difference scores between the Baseline mean total duration per day and the mean total duration per day in each of the subsequent phases, expressed as a percentage of the Baseline duration..

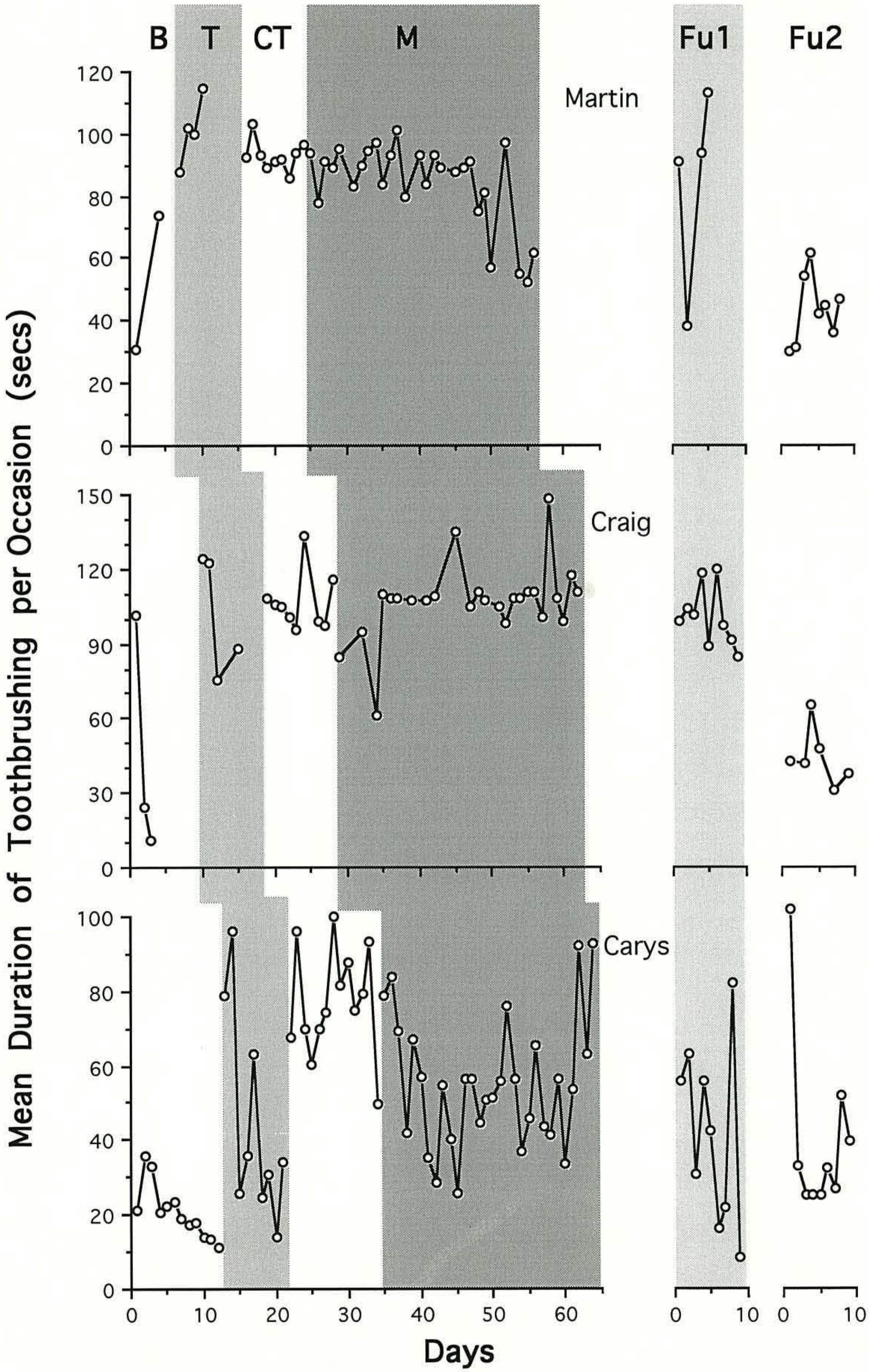
The subjects' mean frequency of toothbrushing was not much different in Baseline (B) and the second condition (T), but all three subjects increased the total amount of time they spent brushing their teeth each day when the Toothtutor was first introduced. Total durations declined, however, in all cases after the first few days. Martin and Craig clearly increased their frequency of toothbrushing after the introduction of Compliance Training, and clear well sustained increases in total duration per day can be seen for all subjects in this condition (CT). Martin increased his mean total duration per day to 906% above Baseline, Craig's mean of 202.9 secs. was thirteen times his Baseline level, and Carys improved her mean by 282%. All three children continued to brush consistently well in the Maintenance phase (M). As noted previously, Martin's and Craig's durations per occasion were exceptionally stable, so the variability in total duration levels seen in their Maintenance data can be attributed mainly to fluctuations in toothbrushing frequency.

Martin did not brush often in the evenings during the first Follow-up (Fu1). His parents indicated that at this time there was a severe family crisis, and this could have affected the results. Nevertheless, despite the low frequency in this condition, because Martin's durations per occasion were so high (see Figure 3.2.2 and Table 3.2.3), his mean total duration per day was still 173% above the Baseline level. Even though Martin's durations per occasion were much lower in the second Follow-up (Fu2), when the Toothtutor was no longer present, his mean total duration per day was higher, because he had improved his frequency. Craig's mean total duration of 157 secs. in the first Follow-up was 938% higher than in Baseline, and although this was reduced to 40 secs. in the second Follow-up, it was still 162% higher than in Baseline. Carys' mean total durations were similar in the two Follow-up conditions (96% and 81% above the Baseline level).

Figure 3.2.2

Mean duration of toothbrushing per occasion per day for each subject during Baseline (B), Toothtutor (T), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). These data were calculated by totalling all the recorded durations each day, and dividing this sum by the daily frequency.

Figure 3.2.2



B
T
CT
M
Fu1
Fu2
Martin
Craig
Carys
Mean Duration of Toothbrushing per Occasion (secs)
120
100
80
60
40
20
0
150
120
90
60
30
0
100
80
60
40
20
0
0
10
20
30
40
50
60
0
10
0
10
Days

TABLE 3.2.3

Mean Duration of Toothbrushing per Occasion

Experiment 4

Each subject's mean duration of toothbrushing per occasion per day, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Toothtutor (T), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions					
	B	**T**	**CT**	**M**	**Fu1**	**Fu2**
Martin						
Mean	52.50	101.13	93.00	84.28	84.00	43.50
Std D	30.41	10.85	4.89	13.38	32.18	10.95
N	2	4	9	27	4	8
Min	31.00	88.00	85.50	52.00	38.00	30.50
Max	74.00	114.50	103.00	101.00	113.00	62.00
Craig						
Mean	45.33	102.25	106.61	107.02	100.40	44.33
Std D	48.65	24.55	11.88	15.30	11.99	11.52
N	3	4	9	25	9	6
Min	11.00	75.00	95.50	61.00	85.00	31.00
Max	101.00	124.00	133.50	148.00	119.50	65.00
Carys						
Mean	20.83	44.78	79.63	55.00	41.89	40.22
Std D	7.44	27.93	12.38	17.18	24.37	25.16
N	12	9	12	31	9	9
Min	11.00	14.00	60.50	25.50	8.50	25.00
Max	36.00	96.00	100.00	92.50	82.00	103.00
Overall Mean	39.55	82.72	93.08	82.10	75.43	42.68

Figure 3.2.3

Total duration of toothbrushing per day for each of the subjects during Baseline (B), Toothtutor (T), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). Data for this figure were calculated by totalling known durations of all toothbrushing events that occurred on each day.

Figure 3.2.3

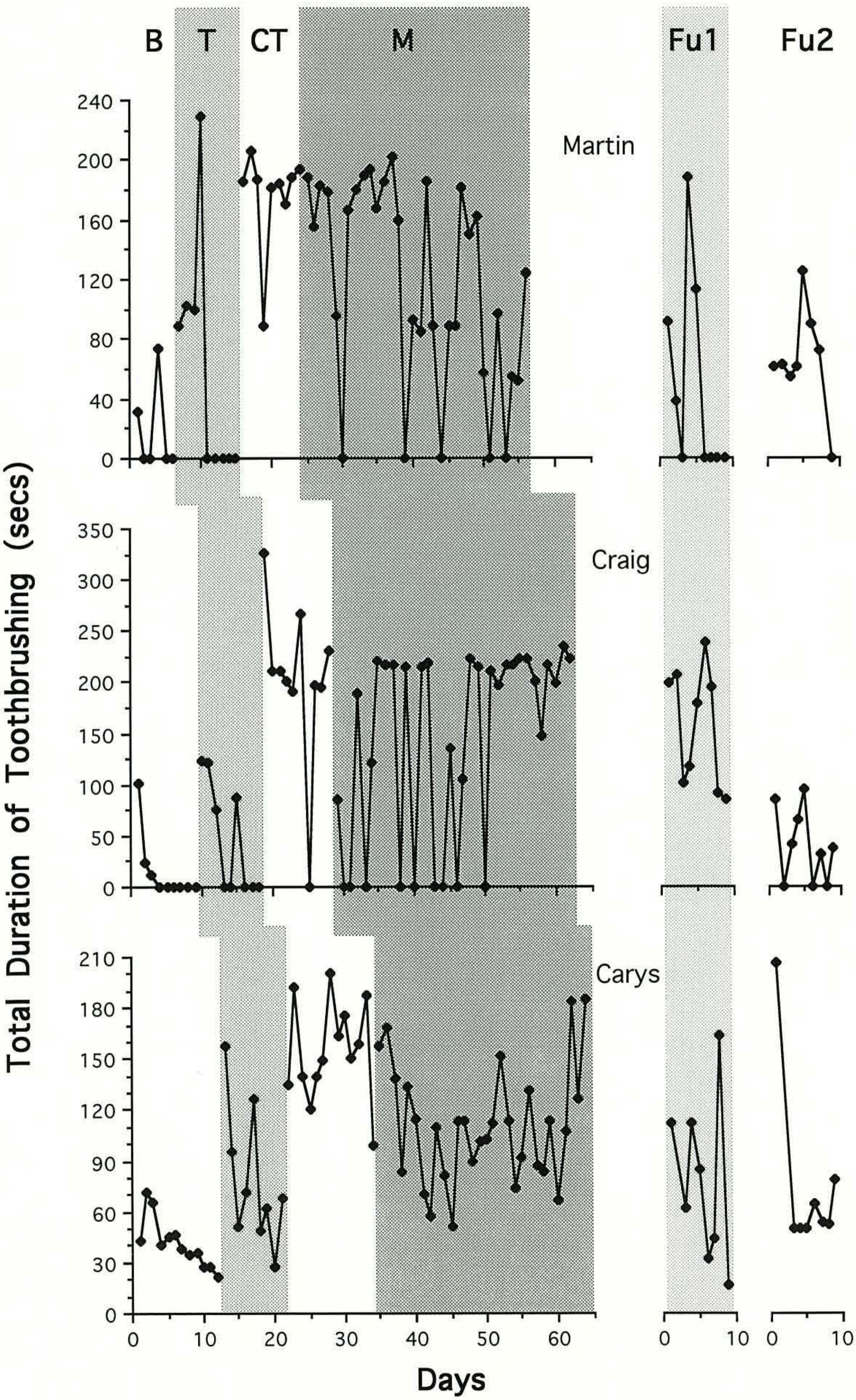
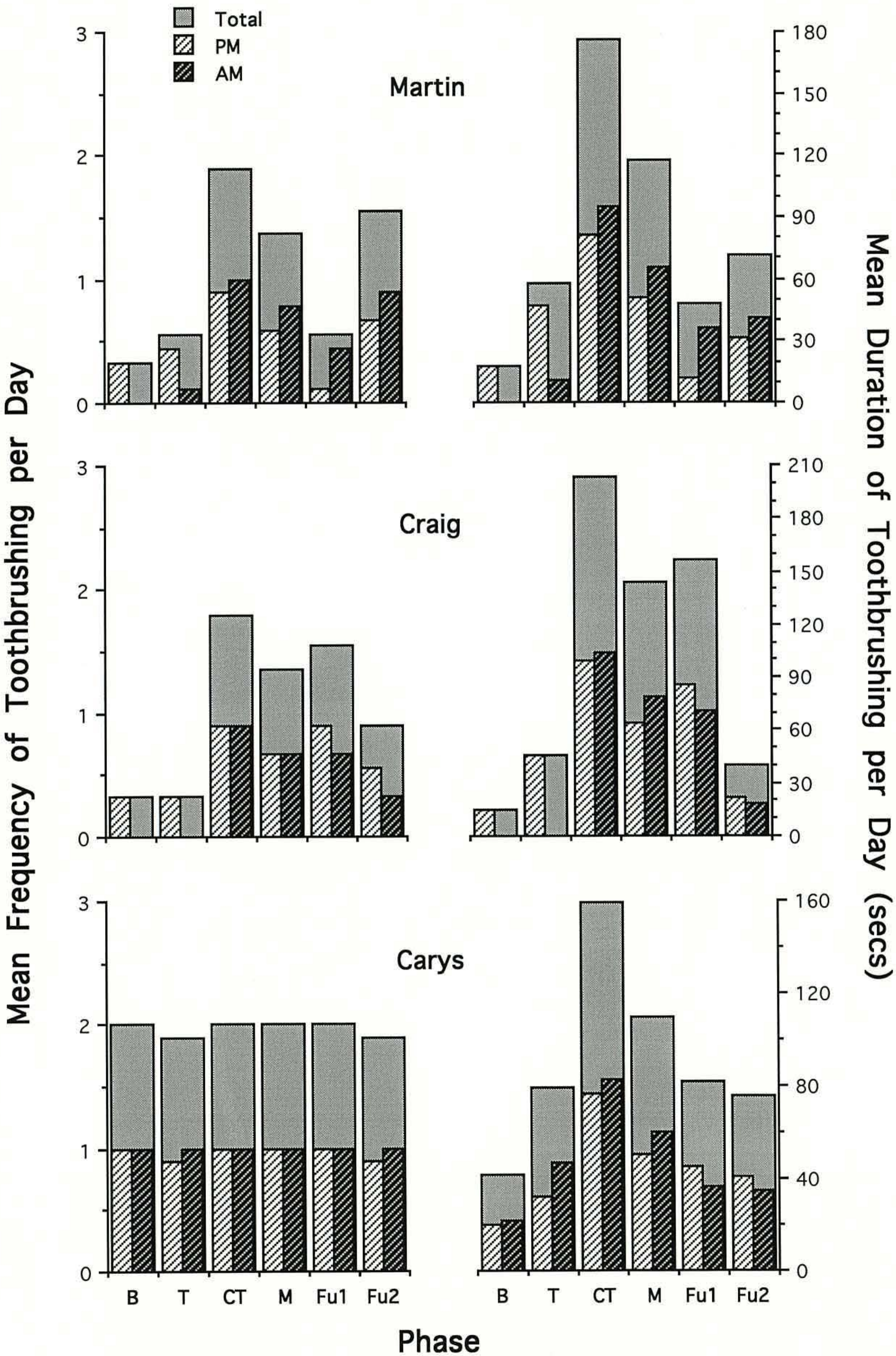

B
T
CT
M
Fu1
Fu2
Martin
Craig
Carys
Total Duration of Toothbrushing (secs)
Days
240
200
160
120
80
40
0
350
300
250
200
150
100
50
0
210
180
150
120
90
60
30
0
0
10
20
30
40
50
60
0
10
0
10

Figure 3.2.4

The mean frequency of toothbrushing per day (left side) and the mean total duration of brushing per day (right side) for each subject in each of the phases. The means for evening (light diagonal line shading) and morning sessions (dark diagonal line shading) in each phase are also shown. Data for the frequency graph (left side) were calculated by totalling the number of brushing events that occurred at night and in the morning, and dividing by the total number of days in the phase. Data for the duration graph were calculated by totalling each subject's known durations at night and in the morning in each phase and dividing by the total number of sessions (of known duration) in the phase.

Figure 3.2.4



Total
PM
AM
Martin
Craig
Carys
Mean Frequency of Toothbrushing per Day
Mean Duration of Toothbrushing per Day (secs)
0
1
2
3
0
30
60
90
120
150
180
210
0
40
80
120
160
B
T
CT
M
Fu1
Fu2
Phase

TABLE 3.2.4

Mean Total Duration Difference Scores

Experiment 4

The percentage difference between each subject's Baseline mean total duration per day and his/her mean total duration per day in all subsequent phases: Toothtutor (T), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Sessions	Experimental Conditions				
	T	**CT**	**M**	**Fu1**	**Fu2**
Martin					
PM	170%	365%	193%	- 34.6%	76%
AM	944%	9378%	6503%	3533%	4000%
Total	**230%**	**906%**	**570%**	**173%**	**311%**
Craig					
PM	201%	559%	326%	470%	40%
AM	0%	10240%	7803%	6978%	1733%
Total	**201%**	**1243%**	**849%**	**938%**	**162%**
Carys					
PM	61%	287%	154%	128%	106%
AM	115%	278%	173%	67%	59%
Total	**89%**	**282%**	**164%**	**96%**	**81%**
Overall Mean	**145%**	**610%**	**399%**	**288%**	**147%**

Although the contingencies affected brushing both at night and in the mornings, in common with the majority of those subjects in the first three experiments who did not brush their teeth twice a day in Baseline, Martin and Craig maintained improvements in their toothbrushing performance in the Follow-ups more effectively in the mornings than at night.

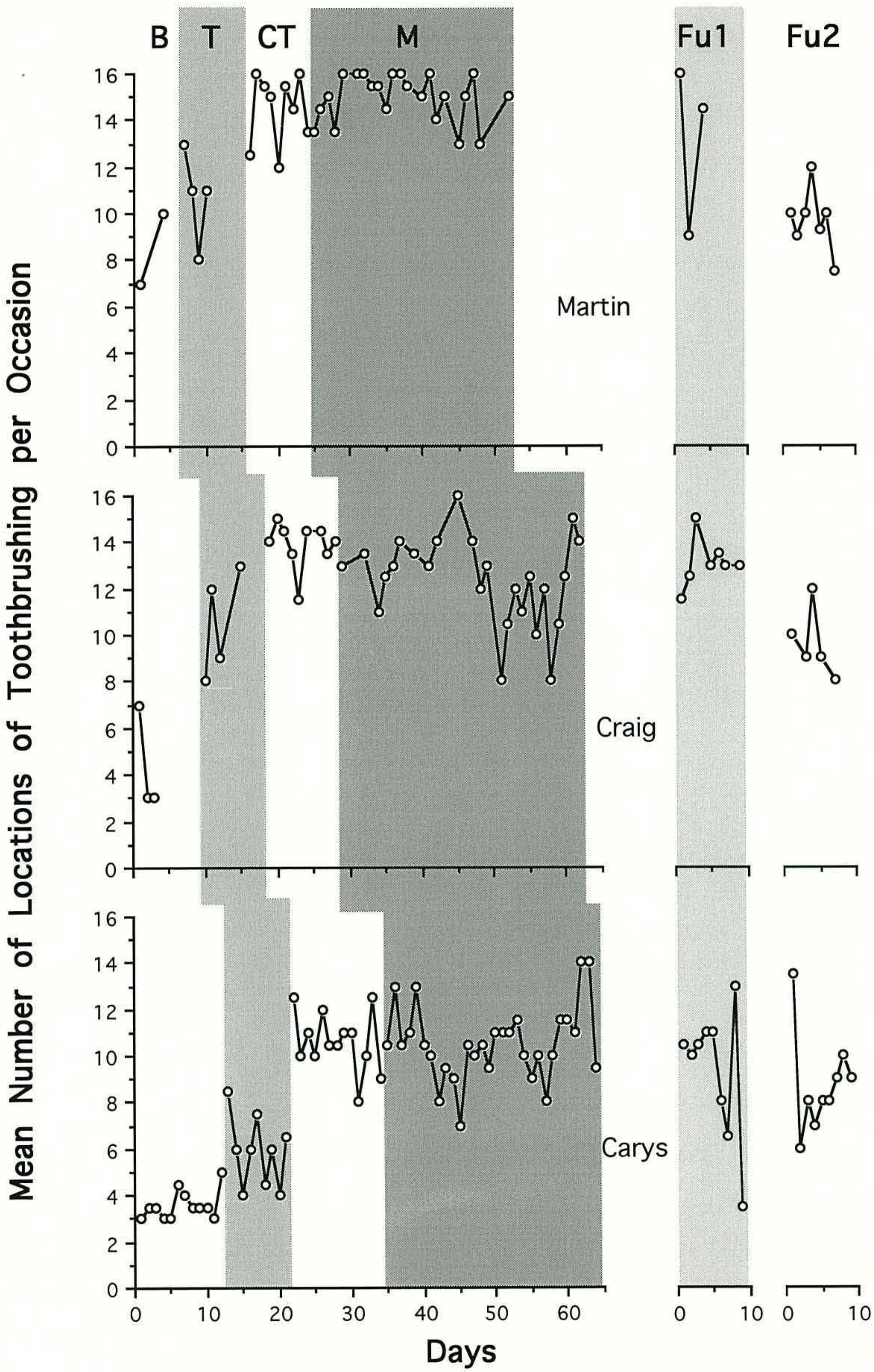
Locations of Toothbrushing

Figure 3.2.5 and Table 3.2.5 show that, in general, the number of locations brushed per occasion were affected by the intervention conditions in much the same way as the mean durations per occasion, and the effects were well maintained at Follow-up. The mean number of locations brushed per occasion was increased in all cases after the introduction of the Toothtutor, and then again when the Compliance contingency was added. Martin's scores were particularly high and stable during the Compliance (CT) and Maintenance (M) conditions, and his improvements were well sustained in the first Follow-up condition (Fu1). Although he brushed more frequently during the second Follow-up (Fu2) than in Baseline (see Figures 3.2.1 and 3.2.4), Martin was still not able to effectively regulate the locations of his brushing behaviour without the Toothtutor. The change in Craig's and Carys' behaviour was equally apparent after the introduction of the contingencies, but they also clearly brushed more locations per occasion in the second Follow-up, without the Tutor, than they did in Baseline.

Figure 3.2.5

Mean number of locations brushed per occasion per day for each subject during Baseline (B), Toothtutor (T), Compliance Training + Toothtutor (CT), Maintenance (M) and both two month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). These data were calculated by adding together the number of locations brushed on each occasion each day, and dividing this sum by the frequency.

Figure 3.2.5



B
T
CT
M
Fu1
Fu2
Mean Number of Locations of Toothbrushing per Occasion
Martin
Craig
Carys
Days
0
2
4
6
8
10
12
14
16
0
10
20
30
40
50
60

TABLE 3.2.5

Mean Number of Locations Brushed per Occasion

Experiment 4

Each subject's mean number of locations brushed per occasion, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Toothtutor (T), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions					
	B	**T**	**CT**	**M**	**Fu1**	**Fu2**
Martin						
Mean	8.50	10.75	14.50	14.98	13.17	9.69
Std D	2.12	2.06	1.50	1.02	3.69	1.36
N	2	4	9	22	3	7
Min	7.00	8.00	12.00	13.00	9.00	7.50
Max	10.00	13.00	16.00	16.00	16.00	12.00
Craig						
Mean	4.33	10.50	13.89	12.34	13.07	9.60
Std D	2.31	2.38	1.02	1.94	1.06	1.52
N	3	4	9	25	7	5
Min	3.00	8.00	11.50	8.00	11.50	8.00
Max	7.00	13.00	15.00	16.00	15.00	12.00
Carys						
Mean	3.58	5.89	10.75	10.47	9.33	8.72
Std D	0.63	1.54	1.25	1.60	2.87	2.14
N	12	9	12	31	9	9
Min	3.00	4.00	8.00	7.00	3.50	6.00
Max	5.00	8.50	12.50	14.00	13.00	13.50
Overall Mean	5.47	9.05	13.05	12.60	11.86	9.33

DISCUSSION

This experiment has shown that exposing the children to the Toothtutor without imposing any contingencies does not have the same effects as exposing them to a condition in which the Toothtutor is incorporated into the Compliance Training procedure. The two subjects (Martin and Craig) who brushed infrequently during Baseline, increased their frequency, duration, and number of locations of toothbrushing immediately after the introduction of the Toothtutor, but their performances returned to Baseline levels three or four days later. Carys, who brushed regularly twice a day thoughout the study, increased her durations of toothbrushing per occasion immediately when the Toothtutor was introduced, but her durations declined rapidly back to Baseline levels within a few days. These results show that, without a contingency placed upon improving behaviour, the Toothtutor alone will not lead to lasting beneficial changes in children's toothbrushing behaviour.

Experiment 3 provided evidence that, when exposed to a procedure that incorporates both the Toothtutor and Compliance Training, children will substantially increase their overall brushing durations, and regulate the locations of their brushing behaviour more effectively. The results form Experiment 4 add to this evidence, because it was only after the introduction of the Compliance Training contingency, that all the subjects brushed twice a day on most days, and showed clear well sustained increases in total durations per day and number of locations brushed per occasion.

Although there is obvious evidence for a novelty effect on durations and number of locations brushed in the data for all three subjects in the Toothtutor Only condition, unlike Experiment 3, there is not a clear downward trend in the duration data during the Compliance Training + Toothtutor or the Maintenance conditions. The reason for this difference is unclear, but it could be due to the difference in the sequence of experimental interventions. Because the subjects participating in Experiment 3 were exposed to the Compliance Training contingency at least nine days before the introduction of the Toothtutor, they were able to gain many more rewards (books, toys and games) than the subjects in Experiment 4, and it is possible that these rewards began to lose their reinforcing function, thus accounting for the decline in performance.

As in Experiment 3, long term maintenance was generally superior in the presence of the Toothtutor (Follow-up 1) than in its absence (Follow-up 2), and there was a greater decline in mean durations per occasion than the number of locations brushed per occasion. This adds to the evidence from Experiment 3 that, two months after the end of the Maintenance condition, the presence of the Toothtutor controlled brushing durations to a greater extent than the number of locations brushed.

3.3 GENERAL RESULTS

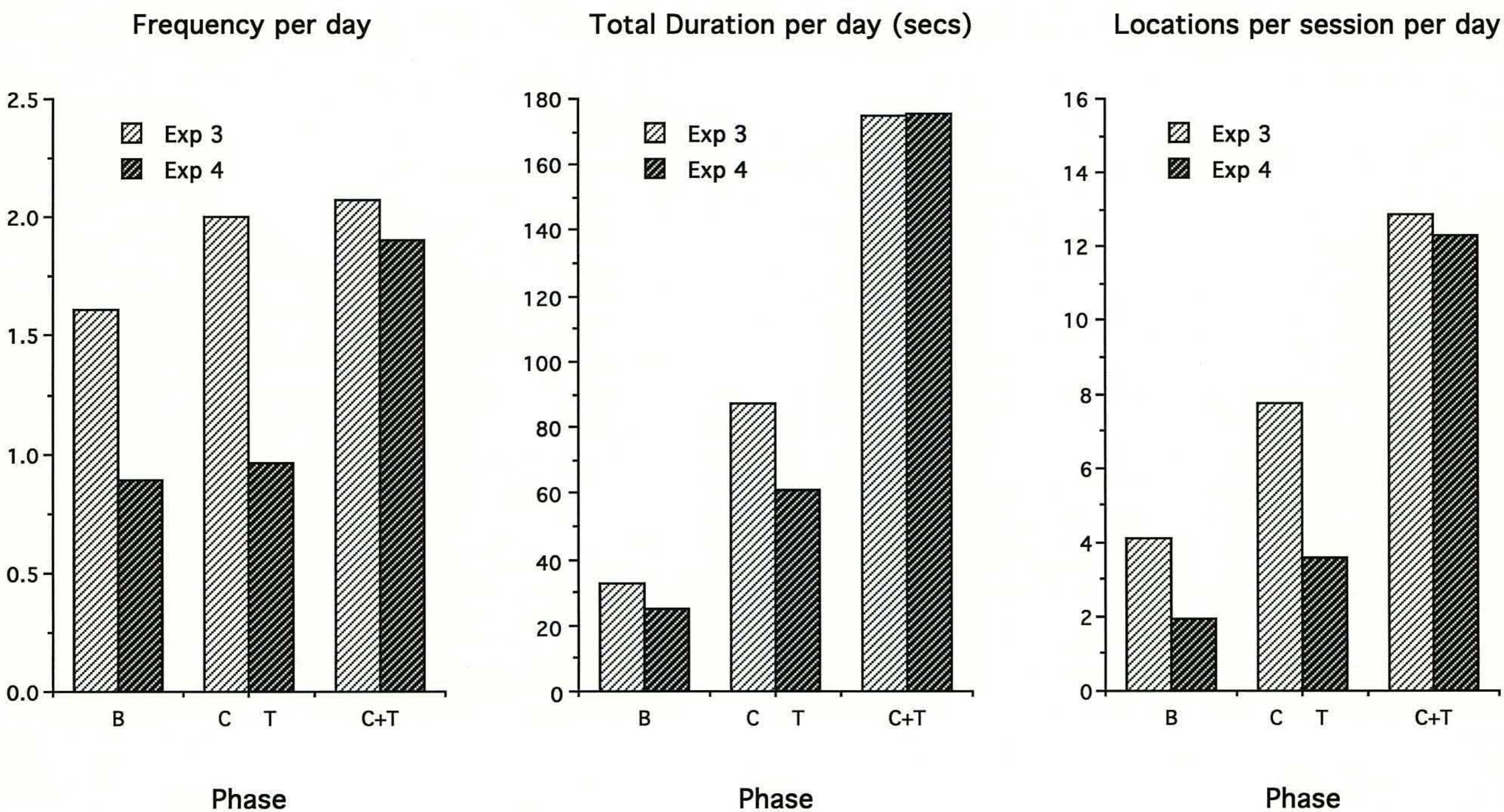
Presented in this section are inter-experimental comparisons of data from only very few subjects. Some of these comparisons should be treated as rough descriptive data which may be indicative, but from which no firm conclusions can be drawn. Further large between-group studies would need to be conducted to confirm the findings indicated by this work.

Figure 3.3.1 shows an overall comparison of the effects of the interventions in Experiments 3 and 4. In both experiments behaviour during the Compliance Training + Toothtutor intervention condition (C+T) was superior to that in any other condition. This is true for all three measures. Introducing the Tutor alone (T) in Experiment 4 increased the mean duration of toothbrushing, and the average number of locations brushed, but did not affect frequency of toothbrushing. Mean frequency, durations and number of locations were all improved in Experiment 3 after the introduction of Compliance Training (C), but far greater duration and location levels were achieved in both experiments during the Compliance Training + Toothtutor condition. These results clearly indicate that a behaviour change package that includes both the Toothtutor device and the Compliance Training contingencies would be more effective than one that includes only the Toothtutor device or Compliance Training alone.

Figure 3.3.1

The mean frequency of toothbrushing per day (left side), the mean total duration of brushing per day (middle) and mean number of locations brushed per session per day (right side) for all subjects in each of three conditions in Experiment 3 (light diagonal line shading), Baseline (B), Compliance Training (C), and Compliance Training + Toothtutor (C+T); and three conditions in Experiment 4 (dark diagonal line shading), Baseline (B), Toothtutor (T), and Compliance Training + Toothtutor (C+T).

Data for the frequency graph were calculated by totalling each subject's mean frequency for the phase and dividing by the number of subjects. Data for the duration graph were calculated by totalling each subject's mean total duration per day in each phase and dividing by the number of subjects. Data for the location graph were calculated by totalling each subject's mean number of locations per session per day in each phase and dividing by the number of subjects.



Frequency per day
Total Duration per day (secs)
Locations per session per day
Exp 3
Exp 4
B
C
T
C+T
Phase
0.0
0.5
1.0
1.5
2.0
2.5
0
20
40
60
80
100
120
140
160
180
2
4
6
8
10
12
14
16

Figure 3.3.1

Figure 3.3.2 depicts the mean total duration per day in the first pair of experiments (Experiments 1 & 2) and the mean total duration per day in the second pair (Experiments 3 & 4). Presented in Table 3.3.1 is the mean frequency and the mean duration per occasion across all subjects in five conditions of (i) Experiments 1&2 combined and, (ii) Experiments 3&4 combined. The minimum and maximum values of subject means are also shown.

It can be seen from Figure 3.3.2 that although the contingencies in Experiments 1 and 2 effectively increased the mean total duration levels (to over 80 seconds), the mean duration value during training with the Toothtutor in Experiments 3 and 4 was much greater (more than 175 secs.). Table 3.3.1 shows that during the training conditions (DC in Experiments 1&2, and CT in Experiments 3&4) although the mean frequencies were almost the same (1.98 and 1.99 respectively), Subjects in Experiments 3&4 (who were exposed to the Toothtutor) spent on average per occasion that they brushed more than twice as long as the subjects in Experiments 1&2. Indeed, during training with the Toothtutor *all* the subjects in the second pair of experiments tended to brush for longer than *any* of the subjects in Experiments 1&2, who did not have the benefit of exposure to the Toothtutor (see Table 3.3.1 minimum and maximum duration values).

Figure 3.3.2

Mean total duration of toothbrushing per day for all subjects in each of four conditions in Experiments 1 and 2 (left side), Baseline (B), Duration Correspondence/Compliance Training (C), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it); and four conditions in Experiments 3 and 4 (right side), Baseline (B), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 and Fu2). The data were calculated by totalling each subject's mean total duration per day in each phase and dividing by the total number of subjects in each pair of experiments.

Figure 3.3.2

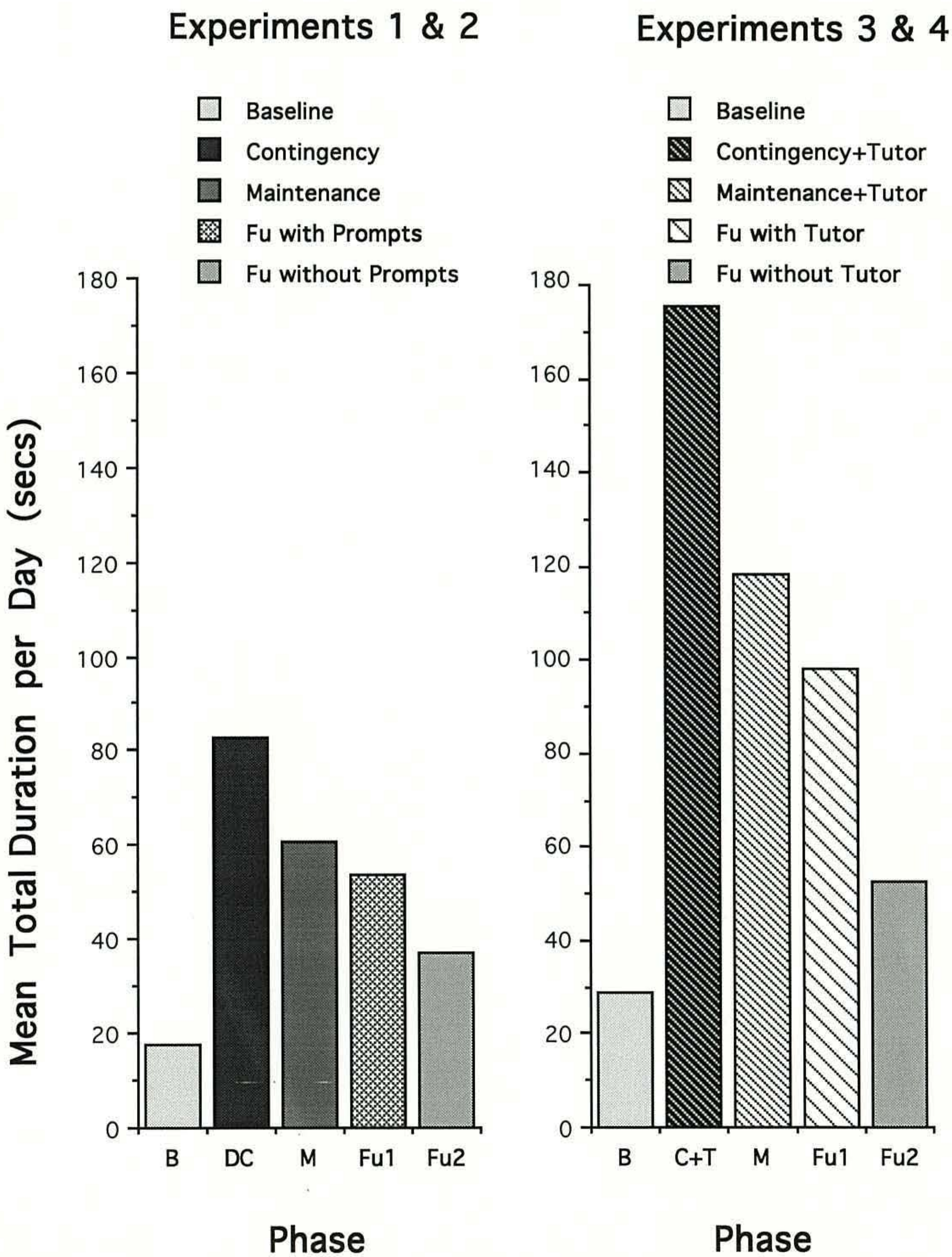

Experiments 1 & 2
Baseline
Contingency
Maintenance
Fu with Prompts
Fu without Prompts
Mean Total Duration per Day (secs)
0
20
40
60
80
100
120
140
160
180
B
DC
M
Fu1
Fu2
Phase
Experiments 3 & 4
Baseline
Contingency+Tutor
Maintenance+Tutor
Fu with Tutor
Fu without Tutor
0
20
40
60
80
100
120
140
160
180
B
C+T
M
Fu1
Fu2
Phase

TABLE 3.3.1

Mean Frequency and Duration per Occasion

Experiments 1 & 2 versus Experiments 3 & 4

The mean frequency and mean duration of toothbrushing per occasion per day in 5 conditions in Experiments 1 & 2, Baseline (B), Duration Correspondence/Compliance Training (DC), Maintenance (M) and both two-month Follow-ups (Fu1 and Fu2), and 5 conditions in Experiments 3 & 4, Baseline (B), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). The minimum and maximum values of subject means are also shown.

EXPERIMENTS 1&2	Experimental Conditions				
N = 10 subjects	**B**	**DC**	**M**	**Fu1**	**Fu2**
FREQUENCY					
Mean	**0.71**	**1.98**	**1.86**	**1.70**	**1.53**
Min	0	1.83	1.73	1.00	0.75
Max	1.50	2.05	2.00	2.00	2.00
DURATION					
Mean	**22.43***	**41.85**	**32.63**	**30.66**	**25.43**
Min	10.75	28.05	19.63	16.33	6.50
Max	47.75	59.37	49.20	48.88	74.25

EXPERIMENTS 3&4	Experimental Conditions				
N = 6 subjects	**B**	**CT**	**M**	**Fu1**	**Fu2**
FREQUENCY					
Mean	**1.25**	**1.99**	**1.70**	**1.56**	**1.56**
Min	0.33	1.80	1.35	0.56	0.89
Max	2.00	2.20	2.00	2.11	1.89
DURATION					
Mean	**29.16**	**88.98**	**71.45**	**64.70**	**34.35**
Min	11.31	59.57	35.62	32.83	16.69
Max	52.50	106.61	107.02	100.40	44.33

* Data from only seven subjects since in three cases there are insufficient occasions of brushing for meaningful data analysis.

The data from the Maintenance and Follow-up conditions confirm that subjects who were exposed to the Toothtutor tended to brush for longer than those were not. It can be seen from Figure 3.3.2 that when in Follow-up 2 of Experiments 3&4 the Toothtutors were removed, the mean total duration declined to about half the value in Follow-up 1, indicating that higher durations were dependent on the presence of the Toothtutor. Indeed Table 3.3.1 shows that for Experiments 3&4 the mean frequency in the two Follow-ups was the same (1.56 times per day), but that the mean duration per occasion was greatly reduced in Follow-up 2.

It should be noted that during Baseline the subjects in Experiments 3&4 generally brushed more frequently and for longer on each occasion than the subjects in Experiments 1&2. Given this difference, and as mentioned earlier, one should be particularly cautious about drawing firm conclusions from the inter-experimental comparative data presented in this section. Nevertheless, despite the problems of comparing results across experiments with small numbers of subjects, the data presented in Figure 3.3.2 and Table 3.3.1, added to those presented in Figure 3.3.1 and in previous sections of this chapter, suggest that a behaviour change package that includes both the Toothtutor device and the Compliance Training contingencies is the most successful intervention yet described in this thesis.

3.4 GENERAL DISCUSSION

Experiments 3 and 4 indicate that, when the Toothtutor is introduced into the Compliance Training procedure, children are better able to regulate the amount of time they spend brushing their teeth, and better able to regulate the locations of their brushing behaviour. During training the children in these experiments brushed twice a day almost every day, they brushed a high proportion of tooth surfaces, and on average they spent close to 90 seconds per occasion. When the subjects in Experiment 3 were exposed to the Compliance Training + Toothtutor intervention, they improved their performance well beyond the level achieved without the Tutor. The subjects in Experiment 4, when exposed to the same intervention, improved performance well beyond that achieved without the Compliance Training contingency.

Although we have developed a method that has been shown to substantially improve children's brushing behaviour during training, pragmatic issues remain that need to be addressed in order to enhance the practical utility of this research programme. First, if as previously stated, one main objective is to develop a comprehensive behaviour change package that can be used in families anywhere to improve effectively the toothbrushing habits of young children, then it must be demonstrated that the effects of the interventions are not dependent on feedback from video camera evidence. Second, there is as yet no direct evidence that the interventions have led to an improvement in oral hygiene (i.e. a reduction in the level of plaque and dental debris in the mouth).

Third, the maintenance effects need to be improved, because although all the subjects in Experiments 3 and 4 spent on average at least twice as long brushing their teeth each day in Follow-up 1 (when the Toothtutor remained in the bathroom) as they had done in Baseline, some children only spent half as long as they had done during the training phase. Performance during Follow-up 2 (after the removal of the Toothtutor), although usually superior to that in Baseline, was often considerably worse than in the training phases and the first Follow-up.

Malott (1989), in an article entitled *The Acheivement of Evasive Goals,* discusses in terms of a behaviour analytic perspective on rule-governance the complex behavioural problems that we encounter in everyday life. He suggests, as many behaviour analysts before him, that to be effective, the consequences of human operant behaviour "must be immediate, probable and sizable" (p.269), but also considers ways in which consequences that are not immediate, probable and sizable "might indirectly control rule-governed behavior" (p.270). Malott notes that in the area of self-management, self-control, and rule-governed behaviour behaviour analysts address the problem of delayed consequences and whether or not they control behaviour. He suggests, however, that in most everyday instances people do not have problems with delayed consequences, but rather with small and cumulating consequences. Malott argues, for example, that since one single instance of a particular dental hygiene behaviour performed on any one day alone does not result in a clean bill of health six months later, this outcome does not reinforce the behaviour. The problem is that each response produces an outcome that is too small to reinforce the behaviour.

Whether this is true or not, the current research has provided probable and sizable consequences for toothbrushing during training. It may be that when these consequences are withdrawn, immediate and probable but less sizable outcomes can be introduced to maintain control of children's toothbrushing. The two experiments described in the next chapter were designed to examine a procedure that attempts to make the natural consequences of toothbrushing more immediately and frequently apparent. They were also designed to determine the effects on oral hygiene of interventions that do not depend on video camera evidence.

CHAPTER 4.

BEHAVIOURAL FEEDBACK: THE EFFECTS OF INTRODUCING DENTAL HYGIENE TESTS.

4.1 EXPERIMENT 5

Chapter 2 described how two different behaviour change interventions could be employed to improve successfully the frequency and duration of children's toothbrushing. The two experiments described in Chapter 3 examined an attempt to gain further control of children's toothbrushing by introducing additional *antecedent* stimuli in the form of a stimulus control device (the Toothtutor). The current chapter will describe two experiments designed to make the 'natural' *consequences* of toothbrushing more immediately apparent to the children. One method of doing this is to introduce into the procedures a disclosing agent (e.g. erythrosine) that visibly stains plaque and dental debris adhering to the teeth. It was hypothesized that this might promote better long-term maintenance effects than were seen in the previous experiments, because the consequences of 'tracking' are made more immediate and sizable.

One main stated objective of the current research was to develop a method that enhances children's self-control, that is, a method that promotes children's toothbrushing in the absence of their parents. A second objective was to develop a comprehensive behaviour change package that can be used in families anywhere. Experiment 5 was conducted to examine how the behaviour change package, developed in the previous experiments, could be adapted to make it more tractable and useful to the general population, and to demonstrate its clinical worth. Parents, therefore, were no longer given any feedback about their children's behaviour from the video camera evidence.

As an alternative to having the parents monitor the children's toothbrushing behaviour directly, they were taught by a specially-trained instructor to measure dental hygiene using a variation of the *Plaque Control Record* devised by O'Leary, Drake and Naylor in 1972. Parents learned to score the presence or absence of plaque and dental debris, revealed by applying a disclosing agent (12mg of erythrosine), on forty tooth surfaces. During training the parents told their children that in order to gain rewards they should brush twice each day and improve their dental hygiene (as measured using the *Plaque Control Record).* Parent's recorded hygiene test scores throughout the study at times determined by the experimental procedure, and these scores were used as an additional measure of the effects of the interventions.

It should be noted that although dental hygiene was included as a dependent variable in this and subsequent experiments, it cannot be considered an entirely reliable measure, since the reliability of a subject's hygiene score (recorded by a parent) was never independently checked. It was demonstrated only that the parents were *able* to conduct hygiene assessments accurately, but not that they *did* conduct accurate assessments of their children's dental hygiene during the course of the experiments. The reasons for this stem from the core aims of the research (i) to develop a behaviour change package that can be administered at home by parents or carers to improve the toothbrushing behaviour of their children, and (ii) to provide an ecologically valid demonstration of its efficacy. First, since the prime aim was to develop a *behaviour* change package, the primary focus was on *direct* measures of *behaviour* (i.e. frequency, duration and number of locations of toothbrushing were considered the most important dependent variables). Second, although it was hoped that these changes in behaviour would lead to clinically important changes in dental hygiene, regular checks of the reliability of a subject's hygiene scores (recorded by a parent) would require that a trained experimenter (or dental hygienist) visit the house regularly. The regular intrusion of a stranger, who comes in the evenings to inspect the child's teeth after this has already been done by a parent, does not constitute the normal course of events in the average household. Indeed, such a procedure would introduce an important independent variable that may potentially have a profound effect on the outcome of the experiments, and would therefore affect their ecological validity.

The design chosen for Experiment 5 provided an opportunity to address some important theoretical questions. First, how would duration and number of locations of toothbrushing be affected by rewards delivered dependent on increases in hygiene test scores? Second, would the effects on duration and locations be more or less dependent on the presence of the Toothtutor than in Experiments 3 and 4? Third, what would be the relation between the hygiene test scores and frequency, durations and locations of toothbrushing? Fourth, would the hygiene test procedure on its own improve toothbrushing behaviour? And finally, would the hygiene tests and continued feedback about dental hygiene enhance the maintenance effects after training?

METHOD

PARTICIPANTS

(a) **Subjects**

Three children took part in Experiment 5, two boys (Neville and Robert) and a girl (Kirsty). The subjects in this experiment were slightly older than those in previous studies. The mean age was 6 yrs 8 mths, compared with an average of 5 yrs 11 mths in the first four experiments (see Table 4.1.1 for complete subject and sibling details).

(b) **Parents**

In all cases the subject's mother conducted the procedures with instructions from the experimenter. Robert and Kirsty both lived in single parent families.

SETTINGS AND MATERIALS

(a) **Recording**

The same mirror cabinets and recording equipment used in Experiments 1 and 2 were installed for Experiment 5. Although parents were never told anything about the durations and locations of their children's toothbrushing, video recordings were taken daily throughout this study, and the behavioural data was analysed in the same way as for Experiments 3 and 4.

TABLE 4.1.1

AGE OF SUBJECTS AND THEIR SIBLINGS

EXPERIMENT 5

Subject	Age at start	Number of Siblings	Age of Siblings
Neville	6 yrs 7 mths	1	3 yrs
Kirsty	6 yrs 10 mths	0	-
Robert	6 yrs 8 mths	0	-

Mean age of subjects = 6 yrs 8 mths

(b) **Rewards**

The token reinforcement system in the training phases of previous experiments made use of adhesive paper stars and non-decorative calendars, with gifts such as inexpensive games, books and toys as rewards. In this study weekly pocket money replaced the gifts, so that during the Compliance Training phases the subjects were given at the end of each week 10 pence for every gold star on the weekly calendar.

DEPENDENT VARIABLES AND RECORDING

(a) **Target Behaviours**

The dependent variables measured throughout the experiment were: (i) toothbrushing frequency, (ii) toothbrushing duration, (iii) the number of dentition locations brushed during each session, and (iv) in all conditions following Baseline, an index of the level of plaque and dental debris adhering to the teeth (dental hygiene).

Plaque levels were assessed using a variation of O'Leary, Drake and Naylor's *Plaque Control Record* (1972). This method was developed to give a simple reliable index of dental hygiene that is easy to administer. An instructor taught parents to score the presence or absence of plaque, highlighted by a disclosing agent (12mg of erythrosine), on forty separate tooth surfaces (see Figure 4.1.1). Parent training consisted of three one hour sessions on three separate days just prior to the introduction of the "Hygiene Tests" condition of the experiment (see Procedure section for details). No attempt was made to teach the parents to differentiate between varying amounts of plaque on individual tooth surfaces. The "dental hygiene score" was simply the number of tooth surfaces that were clean.

(b) **Reliability**

A second observer independently measured toothbrushing durations and the number of locations brushed from 20% of the recorded toothbrushing occurrences (see General Method section). The overall agreement, calculated using the Frequency Ratio method, was 94.1% for duration and 82.2% for locations. For Neville agreement was 96.2% for duration and 80.8% for locations; for Kirsty it was 92.4% and 85.7% respectively; for Robert it was 94.0% and 80.0%. Correlations between the observers' measures of duration and location respectively were: overall, 0.994 and 0.927; for Neville, 0.997 and 0.934; Kirsty, 0.991 and 0.954; and Robert, 0.993 and 0.894.

The reliability of the parents' hygiene scores could not be assessed directly without destroying the ecological validity of the experiment. Instead, each parent's ability to conduct the hygiene test reliably was checked on a model three times during training. On the last of these occasions agreement between a trained assistant and each of the parents was better than 90% in all cases. Parents' plaque assessment skills were checked again at the end of the Maintenance phase, and then again between the two Follow-up conditions. Agreement during these checks never fell to below 90%.

Figure 4.1.1

A diagram of an open mouth showing the forty surfaces examined by the parents during each hygiene test (a modification of O'Leary, Drake and Naylor's *Plaque Control Record,* 1972).

1-3 Lingual and occlusal surfaces, upper dental arch, right posterior segment.

4-7 Lingual surfaces, upper dental arch, anterior segment.

8-10 Lingual and occlusal surfaces, upper dental arch, left posterior segment.

11-13 Lingual and occlusal surfaces, lower dental arch, right posterior segment.

14-17 Lingual surfaces, lower dental arch, anterior segment.

18-20 Lingual and occlusal surfaces, lower dental arch, left posterior segment.

21-23 Buccal surfaces, upper dental arch, right posterior segment.

24-27 Labial surfaces, upper dental arch, anterior segment.

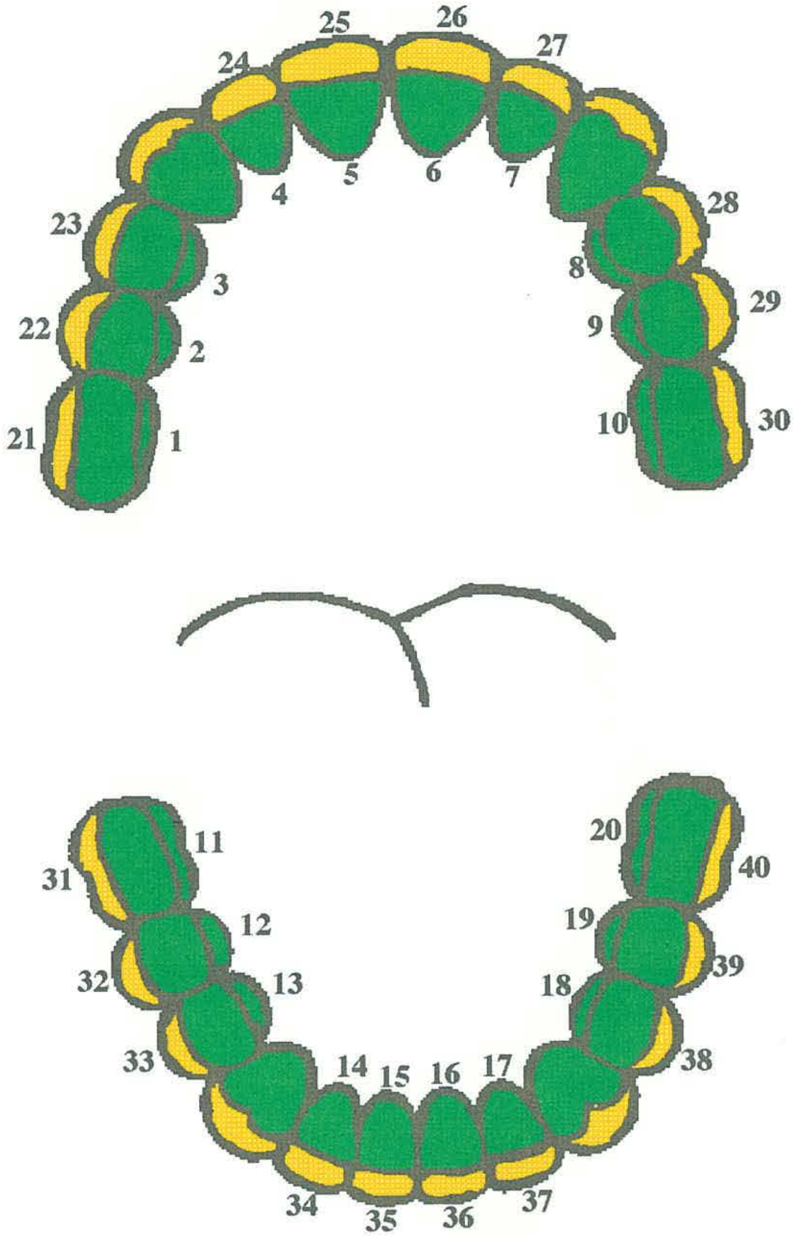
28-30 Buccal surfaces, upper dental arch, left posterior segment.

31-33 Buccal surfaces, lower dental arch, right posterior segment.

34-37 Labial surfaces, lower dental arch, anterior segment.

38-40 Buccal surfaces, lower dental arch, left posterior segment.

Figure 4.1.1



HYGIENE

Experimental Design

Baselines in this experiment were six days (Neville), eight days (Kirsty), and eleven days (Robert). After baseline all of the subjects were exposed to the following sequence of four intervention conditions:

(1) Hygiene Tests

(2) Hygiene Tests + Compliance Training

(3) Hygiene Tests + Compliance Training + Toothtutor

(4) Maintenance of Compliance.

Procedure

Hygiene Tests

Each parent was given individual tuition on how to conduct the hygiene test on three separate occasions before the beginning of this phase. The experimenter and a specially trained instructor visited each family home to conduct the training sessions, which lasted for approximately an hour. The instructor demonstrated the plaque assessment method with the experimenter acting as the model. The parents were trained, as described earlier, until the agreement between the scores given by the instructor, and by the parent, was consistently greater than 90%.

On the first evening of this phase parents escorted their child to the bathroom before bedtime (after the time when the subject would normally have brushed his/her teeth). The parents discreetly removed the toothbrush from the holder, and said:

"I want you to chew this pill, don't swallow it, just chew it until it all turns to liquid. When the pill has all gone, be careful not to swallow any of the liquid. With the liquid still in your mouth, I want you to touch all the parts of your teeth with your tongue. First of all the insides. [The parent shows the inside surfaces of her teeth] Close your mouth, and feel the insides of your teeth with your tongue. First this side, then the front, and then the other side. [The parent demonstrates] If you open your mouth, you can feel the outsides of your teeth with your tongue. [The parent demonstrates] Try it, touch all the tops first, and then all the bottom ones. Now touch the biting parts of your teeth. [Demonstrates] These are the flat parts of your back teeth that have bumpy edges. Can you feel them?"

After this the parent gave a disclosing tablet, and asked the child to chew it. When this was dissolved, the child distributed the liquid to all surfaces of the teeth with the tongue, and then rinsed the mouth with fresh water (3 times). The plaque assessment test, was conducted in good light as demonstrated by the instructor. The whole procedure, which usually lasted for 2 or 3 minutes, was recorded on video and the parents recorded the scores in their diaries.

The assessment tests were repeated every night just before bed time. Parents were asked to avoid discussion about the plaque scores, and to say nothing about the child's oral hygiene.

They were instructed that throughout this condition, and the rest of the study, they should not prompt nor prevent toothbrushing after the tests, or at any other time, and were told to leave the room whenever the subject decided to brush his/her teeth.

Hygiene Tests + Compliance Training

As in the Compliance Training conditions in previous experiments, parents gave their child the following instruction every day:

> *"Every night and every morning, you should brush every part of all your teeth and gums."*

In this condition, however, the instruction was given at night after the hygiene test, rather than in the afternoon before the evening meal (see Experiments 1, 2, 3, & 4). Gold stars and material rewards were contingent upon the child (i) brushing twice each day, once in the morning and once in the evening *before* the hygiene test, and (ii) improving the hygiene score (rather than on increasing brushing duration). Parents told their child:

> *"Every night after I have checked your teeth, I will tell you how clean they are, and if they are very clean, I will put a gold star on the calendar, which means you have earned 10p. If your teeth are very clean every day, you could get 70p at the end of the week. But remember, you should brush your teeth in the morning* ***and*** *at night before I check your teeth. If you forget to brush in the morning, or at night, you won't get a gold star even if your teeth are clean."*

Each day the experimenter decided what the criterion hygiene score should be for each subject and informed the child's parents. The parents carried out the plaque assessments every evening, and if the subject had brushed twice or more (once in the morning and once in the evening prior to the hygiene test), and if the hygiene score was above the criterion level, the parent praised the child, put a gold star on the calendar, and promised an additional 10p for the end of the week. A child who brushed twice, but whose hygiene score was below criterion, was given a silver star and feedback about the performance. A green star was put on the calendar if a child forgot to brush on one occasion. At no time during this, and all following conditions, were the subjects told the meaning of the hygiene scores, or given any information about the numbers recorded in the parents' diaries on any particular day. They were told only whether or not they had brushed their teeth well enough to gain a reward.

Hygiene Tests + Compliance Training + Toothtutor

On the first afternoon of this condition a parent showed the Toothtutor device to the child,. demonstrated its use and gave instructions, as in the Compliance Training + Toothtutor conditions of Experiments 3 and 4. The contingencies remained the same as in the previous phase.

Maintenance of Compliance

The instructions and opportunities for gaining material reward were systematically faded as in the previous experiments. The parents first conducted the hygiene test on the second day. If the subject had brushed twice a day for two days and maintained an above criterion hygiene score, a gold star was placed on the calendar, and three days passed before the next assessment. If after this the subject still brushed frequently and maintained an above criterion hygiene score, assessments were reduced to once a week on randomly assigned days. Although subjects received feedback less frequently than in the previous conditions, they were still able to gain a maximum of 70p per week if they brushed at least twice each day and improved upon, or maintained, a criterion hygiene score.

Follow-up

The Toothtutors were left in the bathrooms and were maintained in working order during the eight weeks between the Maintenance and the Follow-up conditions. Although no video recordings were taken during this period, hygiene tests were conducted weekly on randomly assigned days, and the subjects were still able to earn pocket money (70p per week) for frequent and effective brushing (i.e. the contingencies and criteria remained the same as they were at the end of the Maintenance condition).

In the first Follow-up condition the video equipment was switched on for the nine days of recording with the Tutors still in place. At the end of this phase the Tutors were removed. Two weeks later, in the second Follow-up phase, data was collected for a further nine days. Hygiene tests were conducted once a week throughout, and parents continued to apply the same reward contingencies.

RESULTS

Dental Hygiene

Figure 4.1.2 shows that the hygiene test scores, supplied by each subject's parent, increased rapidly in the absence of a contingency during the second phase of the experiment (H). In all cases, however, Hygiene scores stabilized or decreased during the last three days of this condition. The scores continued to increase, with a clear change in level for Kirsty and Robert, after the introduction of the Compliance contingency (C). Scores improved further after the introduction of the Toothtutor in the next condition (CT), and there was a change in level for all three subjects (especially clear in the case of Neville and Robert). The improved scores were maintained at a high level throughout the next 15 weeks during the Maintenance (M) and Follow-up conditions (Fu1 & Fu2), and the intervening periods (N1 & N2).

Frequency of Toothbrushing

Figure 4.1.3 and Table 4.1.2 shows that none of the subjects in Experiment 5 brushed their teeth regularly twice each day during Baseline (B). Neville brushed his teeth only twice in six days (mornings on both occasions) and Kirsty generally brushed once a day (6 of the 8 occasions were mornings). Both of these subjects brushed twice a day every day for the first few days after the introduction of the Hygiene Tests condition (H). This was because they brushed in the evening *after* the plaque assessment test and then the following morning. Robert brushed almost once a day during Baseline, slightly more frequently in the morning than at night, and he still brushed once a day during the Hygiene Tests condition, but only at night after the hygiene tests.

Figure 4.1.2

The hygiene test scores supplied by each subject's parents during each of the six experimental phases of the study, Hygiene Tests (H), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M), both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it), the 8 week period between Maintenance and Follow-up 1 (N1), and the 2 week period between the two Follow-ups (N2).

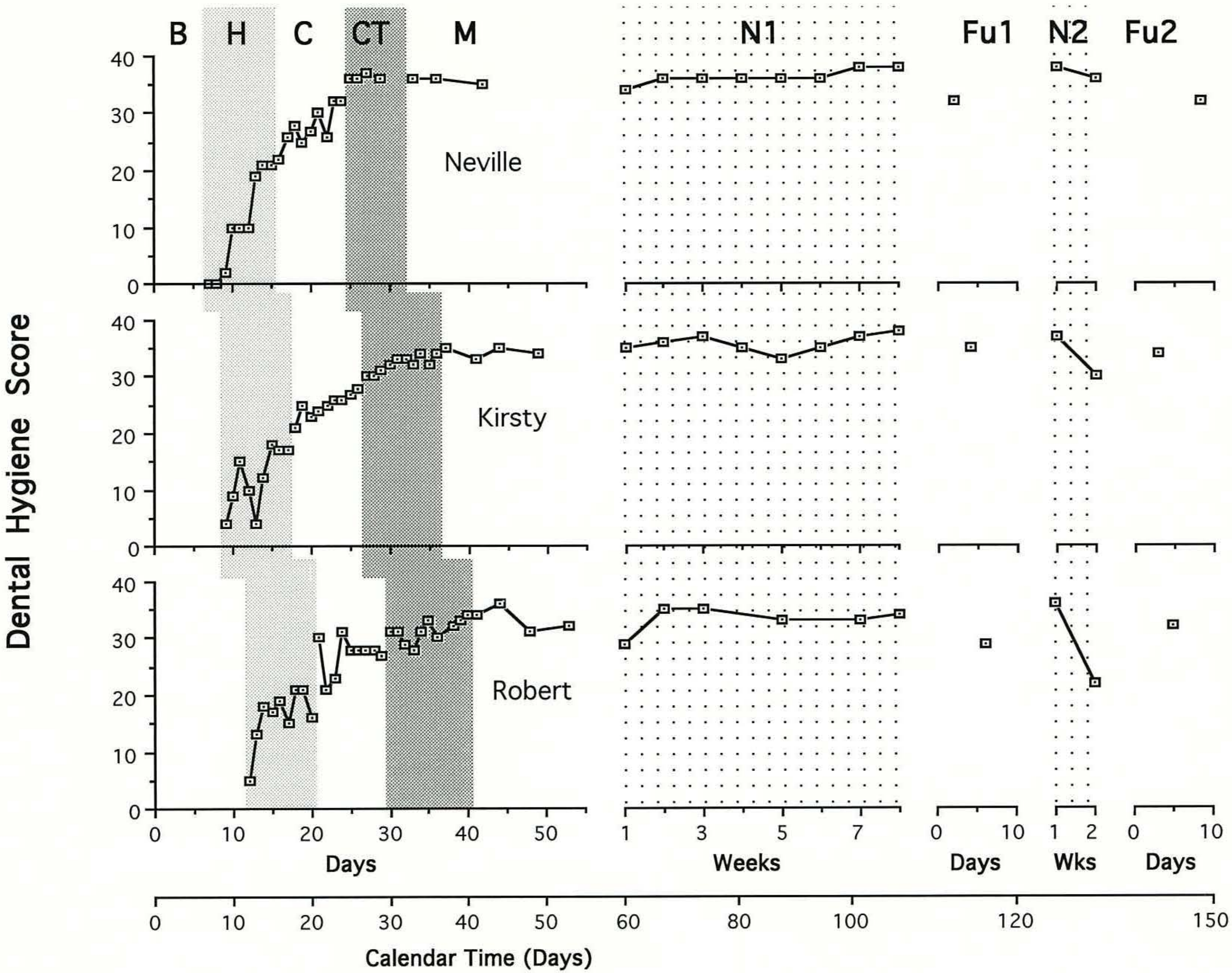

B
H
C
CT
M
N1
Fu1
N2
Fu2
Neville
Kirsty
Robert
Dental Hygiene Score
0
10
20
30
40
Days
Weeks
Wks
Calendar Time (Days)
60
80
100
120
150

Figure 4.1.2

Figure 4.1.3

Frequency of toothbrushing per day for each subject during each condition: Baseline (B), Hygiene Tests (H), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Figure 4.1.3

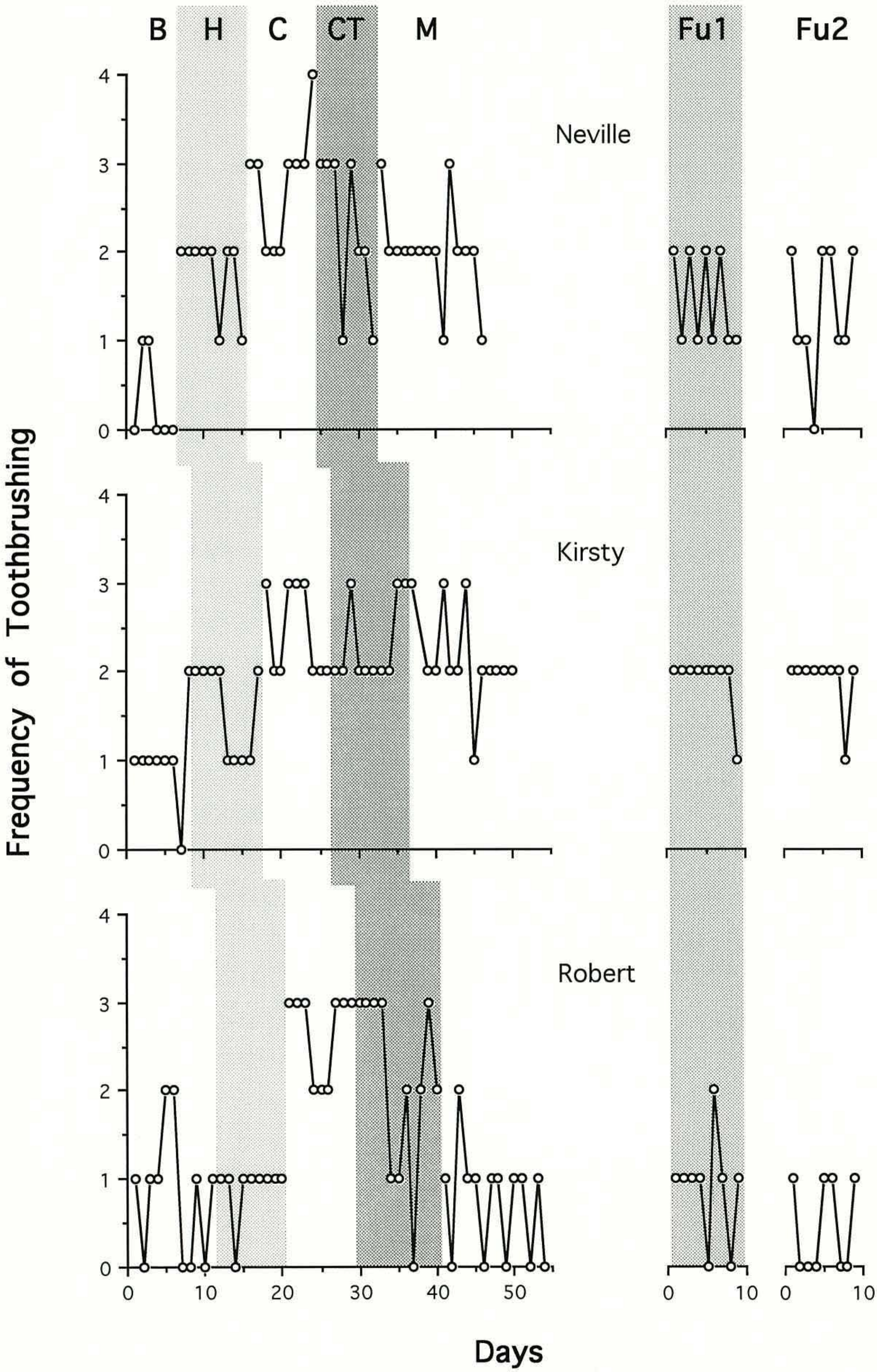

B
H
C
CT
M
Fu1
Fu2
Neville
Kirsty
Robert
Frequency of Toothbrushing
Days
0
1
2
3
4
0
10
20
30
40
50
0
10
0
10

TABLE 4.1.2

Mean Frequency of Toothbrushing

Experiment 5

Each subject's frequency of toothbrushing per day, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Hygiene Tests (H), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions						
	B	**H**	**C**	**CT**	**M**	**Fu1**	**Fu2**
Neville							
Mean	0.33	1.78	2.78	2.25	2.00	1.44	1.33
Std D	0.52	0.44	0.67	0.87	0.56	0.53	0.71
N	6	9	9	8	14	9	9
Range	0 - 1	1 - 2	2 - 4	1 - 3	1 - 3	1 - 2	0 - 2
Kirsty							
Mean	1.00	1.56	2.44	2.30	2.15	1.89	1.89
Std D	0.54	0.53	0.53	0.48	0.56	0.33	0.33
N	8	9	9	10	13	9	9
Range	0 - 2	1 - 2	2 - 3	2 - 3	1 - 3	1 - 2	1 - 2
Robert							
Mean	0.82	0.89	2.67	2.09	0.71	0.89	0.44
Std D	0.75	0.33	0.50	1.04	0.61	0.60	0.53
N	11	9	9	11	14	9	9
Range	0 - 2	0 - 1	2 - 3	0 - 3	0 - 2	0 - 2	0 - 1
Overall Mean	0.72	1.41	2.63	2.21	1.62	1.41	1.22

All three subjects brushed their teeth twice a day or more during the Compliance Training condition (C). Whenever they brushed three times in one day it was twice at night (once before and once after the plaque test) and once in the morning. Kirsty continued to maintain a frequency of two or three times a day every day when the Toothtutor was introduced (CT). Neville did not brush on two evenings during this condition, on the first occasion (Day 23) he fell asleep very early in the evening, and on the second (Day 27) he came home late from a friend's house and went straight to bed. Neville's mother did not carry out the plaque assessment on either of these days. Robert failed to brush on two mornings (Days 34 & 35) during this condition, and one complete 24 hour period (Day 37). On this day he refused to allow his mother to do the plaque assessment, presumably because he knew he had failed to fulfil the contingencies and would not be rewarded.

During the Maintenance condition (M) Neville failed to brush twice a day or more on only two occasions, and Kirsty failed on only one occasion. Robert, however, brushed less frequently than he had done in Baseline. A probable reason for this decline may have been two successive errors made by Robert's mother in carrying out the experimental procedures. First, she misunderstood instructions at the end of the previous condition. Robert should have been rewarded for his performance on the last day of the Compliance Training + Toothtutor phase, but was not. Thus on the first day of Maintenance, contrary to what was intended, Robert was told that he had failed under the current conditions, and that it would now be made even more difficult to gain rewards. Second, Robert was rewarded on the fourth day of Maintenance because his Hygiene Score on this day was good, and his mother thought he had brushed twice a day on both of the previous days. Robert had, in fact, brushed on average only once a day since the beginning of the Maintenance condition. Robert was rewarded again on the thirteenth day of Maintenance (Day 53) even though his frequency of toothbrushing had declined still further.

Neville brushed less frequently during the two-month Follow-ups (Fu1 and Fu2) than during the intervention phases, but more frequently than in Baseline. Kirsty continued to brush regularly, but as result of going to bed very late, she failed to brush her teeth on the last evening of the first Follow-up. She brushed twice a day on every day of the second Follow-up, but because she brushed for less than five seconds on one occasion (Day 8), this event was discounted (see the General Method section in Chapter 2 for an explanation of rationale). Robert's pattern of daily frequencies during Follow-up 1 was similar to that in Baseline, and he brushed less often during Follow-up 2 than during any other condition.

Mean Duration of Toothbrushing per Occasion

Inspection of Figure 4.1.4 and Table 4.1.3 in conjunction with the frequency data shows that although the introduction of the Hygiene Tests procedure (H) resulted in a dramatic increase Neville's frequency of toothbrushing, he spent, on average, less time per occasion than he had done on the two occasions that he brushed in Baseline. Kirsty temporarily increased her durations per occasion immediately after the introduction of the Hygiene

Tests, but after three days her behaviour returned to its Baseline level. All three subjects' mean frequency increased to more than twice a day following the introduction of the Compliance Training contingency, but their mean durations per occasion in this condition (C) were less than in the previous one. Only in the next condition (CT), when the Toothtutors were introduced, was there a uniform substantial increase in duration levels in all cases. Kirsty's mean durations per occasion dropped in the middle of the Compliance Training + Toothtutor condition to a level similar to that in previous conditions, but they increased again at the end of the phase, and her overall mean for this condition was more than 3 times her Baseline level.

Neville's durations per occasion in the Maintenance phase (M), although generally lower than in the previous condition, were much higher than in any of the conditions prior to the introduction of the Toothtutor. The other two subjects brushed for even longer per occasion in Maintenance than they had done during intensive training with the Toothtutor, and both of their means for this condition were more than 4 times their Baseline levels. Although Neville brushed relatively frequently in the Follow-ups (Fu1 and Fu2), he seldom brushed for longer than he had done on the two occasions that he brushed in Baseline. Kirsty's average duration per occasion was far greater in Follow-ups 1 and 2 (62.06 secs. and 31.56 secs. respectively) than in Baseline (14.50 secs.). Robert generally brushed at or below his Baseline level during both Follow-ups, but on two days during Follow-up 1 his mean duration per occasion was more than 70 seconds.

Figure 4.1.4

Mean duration of toothbrushing per occasion per day for each subject during Baseline (B), Hygiene Tests (H), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M), and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). These data were calculated by totalling all the recorded durations each day, and dividing this sum by the daily frequency.

Figure 4.1.4

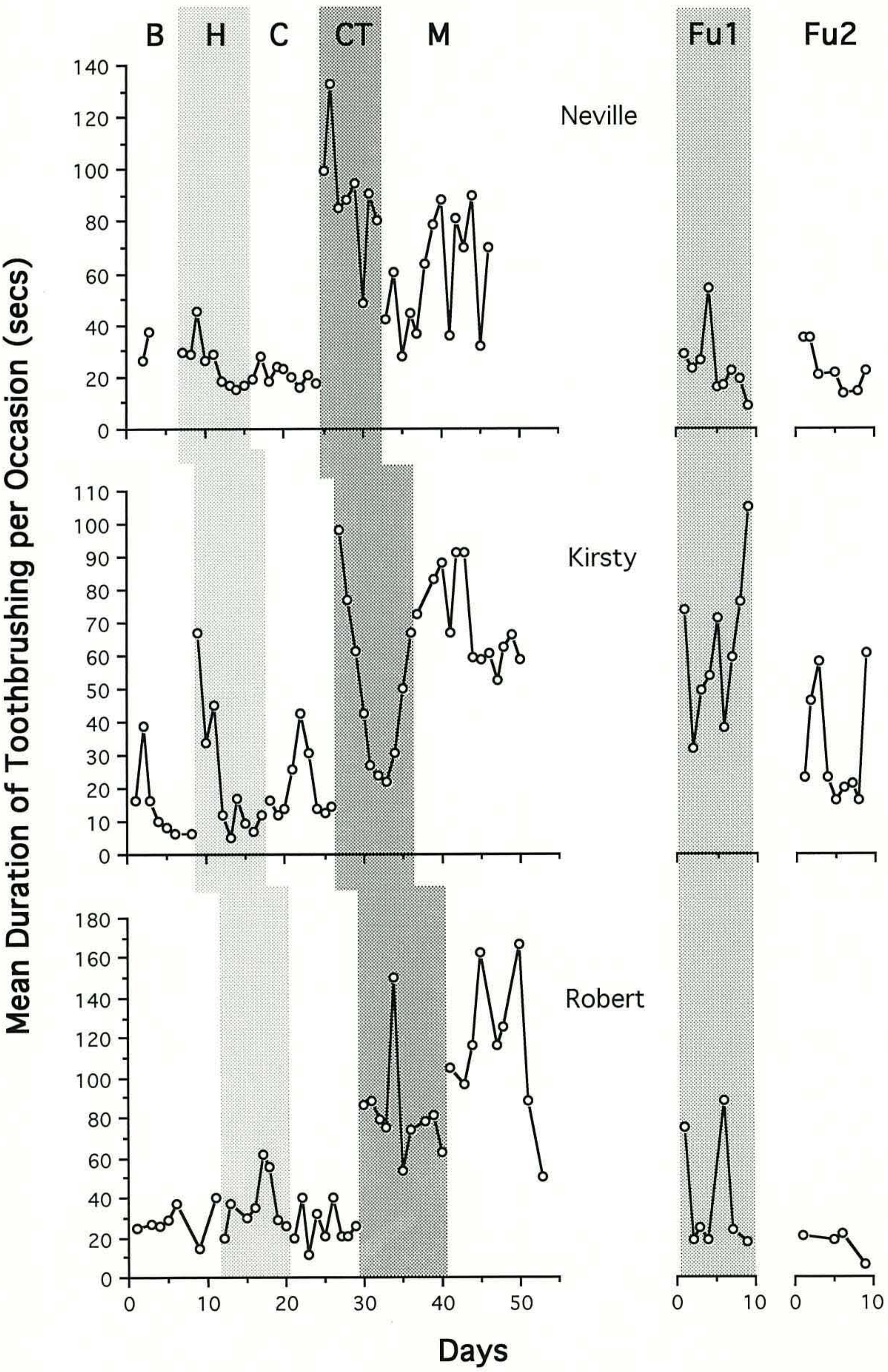

B
H
C
CT
M
Fu1
Fu2
Neville
Kirsty
Robert
Mean Duration of Toothbrushing per Occasion (secs)
Days

TABLE 4.1.3

Mean Duration of Toothbrushing per Occasion

Experiment 5

Each subject's mean duration of toothbrushing per occasion per day, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Hygiene Tests (H), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions						
	B	**H**	**C**	**CT**	**M**	**Fu1**	**Fu2**
Neville							
Mean	31.50	25.06	20.63	89.94	58.60	23.89	23.21
Std D	7.78	9.47	3.75	23.33	21.87	12.72	8.81
N	2	9	9	8	14	9	7
Min	26.00	15.50	15.67	48.50	27.50	9.00	13.50
Max	37.00	45.00	28.00	133.00	89.50	54.00	35.00
Kirsty							
Mean	14.50	23.11	20.09	49.90	70.16	62.06	31.56
Std D	11.57	21.13	10.58	25.54	13.64	22.25	18.07
N	7	9	9	10	13	9	9
Min	6.00	5.00	11.67	22.00	52.50	32.00	16.00
Max	39.00	67.00	42.33	98.00	91.50	105.00	60.50
Robert							
Mean	28.29	36.88	25.48	82.95	114.17	38.00	17.00
Std D	8.52	14.70	9.75	25.72	36.27	30.10	7.44
N	7	8	9	10	9	7	4
Min	14.00	20.00	11.67	54.00	50.00	17.00	6.00
Max	40.00	62.00	40.00	150.00	167.00	88.00	22.00
Overall Mean	24.76	28.35	22.07	74.26	80.98	41.32	23.92

Total Duration of Toothbrushing per Day

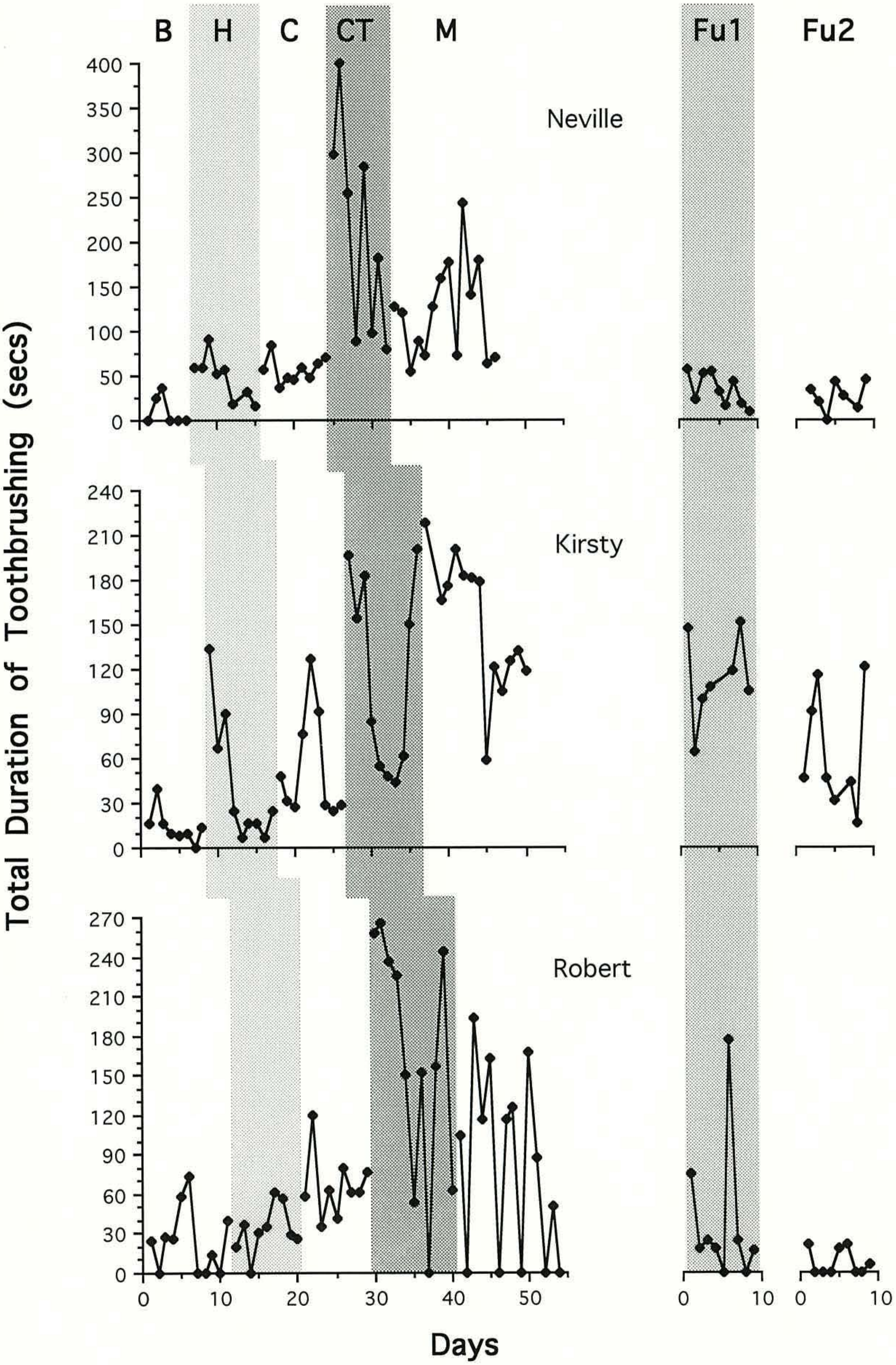
Figure 4.1.5 shows that Neville and Kirsty temporarily increased their total durations of toothbrushing immediately after the introduction of the Hygiene Tests procedure (H), but after a few days their total durations dropped back to Baseline levels. Figure 4.1.6 shows that all three subjects brushed more frequently at night in this condition, and that Neville and Kirsty increased their overall frequency of toothbrushing. Robert's overall frequency and total duration of toothbrushing per day was not much different in the two conditions, because although during the Hygiene Tests condition he brushed more frequently at night, he did not brush at all in the mornings.

The frequency of night time brushing was more than 1.5 times per day in all cases during Compliance Training (C), and all three subjects brushed on most mornings in this condition. This led to slight increases in Neville's and Kirsty's mean total durations, and a much bigger increase in Robert's. Although all three subjects brushed their teeth a little less frequently after the introduction of the Toothtutor in the next condition (CT), they all more than doubled their mean duration per session. Table 4.1.4 shows that Neville's mean total duration per day had increased to 1,904% above his Baseline level, Kirsty's had increased by 740%, and Robert's by 584%.

Figure 4.1.5

Total duration of toothbrushing per day for each of the subjects during Baseline (B), Hygiene Tests (H), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M) and Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). Data for this figure were calculated by totalling known durations of all toothbrushing events that occurred on each day.

Figure 4.1.5



B
H
C
CT
M
Fu1
Fu2
Neville
Kirsty
Robert
Total Duration of Toothbrushing (secs)
Days
400
350
300
250
200
150
100
50
0
240
210
180
150
120
90
60
30
270
0
10
20
30
40
50

Figure 4.1.6

The mean frequency of toothbrushing per day (left side) and the mean total duration of brushing per day (right side) for each subject in each of the phases. The means for evening (light diagonal line shading) and morning sessions (dark diagonal line shading) in each phase are also shown. Data for the frequency graph (left side) were calculated by totalling the number of brushing events that occurred at night and in the morning, and dividing by the total number of days in the phase. Data for the duration graph were calculated by totalling each subject's known durations at night and in the morning in each phase and dividing by the total number of sessions (of known duration) in the phase.

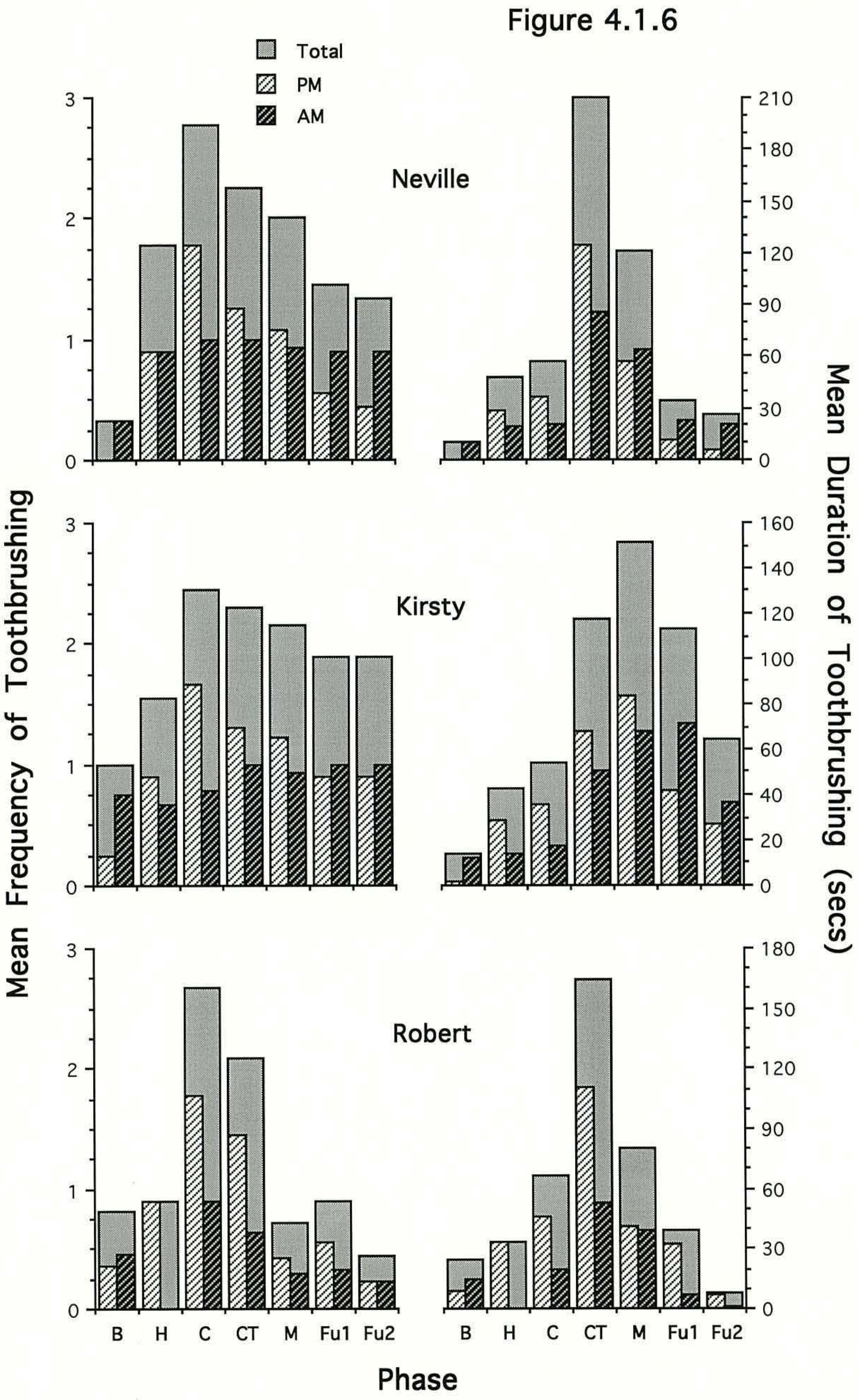


Figure 4.1.6
Total
PM
AM
Neville
Kirsty
Robert
Mean Frequency of Toothbrushing
Mean Duration of Toothbrushing (secs)
B
H
C
CT
M
Fu1
Fu2
Phase

TABLE 4.1.4

Mean Total Duration Difference Scores

Experiment 5

The percentage difference between each subject's Baseline mean total duration per day and his/her mean total duration per day in all subsequent phases: Baseline (B), Hygiene Tests (H), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Sessions	Experimental Conditions					
	H	**C**	**CT**	**M**	**Fu1**	**Fu2**
Neville						
PM	2775%	3556%	12350%	5571%	989%	514%
AM	81%	92%	718%	512%	122%	93%
Total	**355%**	**440%**	**1904%**	**1052%**	**226%**	**152%**
Kirsty						
PM	1249%	1594%	3081%	3831%	1853%	1177%
AM	21%	50%	321%	469%	501%	211%
Total	**207%**	**284%**	**740%**	**979%**	**706%**	**357%**
Robert						
PM	257%	403%	1109%	353%	249%	- 25%
AM	- 93%	161%	259%	161%	- 51%	- 96%
Total	**37%**	**235%**	**584%**	**235%**	**64%**	**- 69%**
Overall Mean	**200%**	**320%**	**1076%**	**755%**	**332%**	**147%**

Although the performance trends during the first three interventions were fairly consistent across subjects, the maintenance effects varied between subjects. In the Maintenance condition (M) Kirsty increased her mean duration per day still further to 979% above her Baseline level, whereas Neville's mean per day fell from more than 210 secs. to 121 secs. (1,052% above Baseline). Robert brushed less frequently than he had done in Baseline, but because he brushed for so much longer on most occasions, his mean total duration per day was still 235% above the Baseline level. Neville, Kirsty and Robert all spent less time brushing per session in Follow-up 1 than in Maintenance, and even less time in Follow-up 2, but Neville's means were still 226% and 152% higher than Baseline. Kirsty brushed for an average of approximately 113 secs. per day in the first Follow-up when the Tutor was present (706% above Baseline) and 64 secs (357% above Baseline) in Follow-up 2. Robert's total duration levels in the Follow-ups, with the exception of one day (Fu 1 Day 6), were similar to or slightly worse than those in Baseline.

None of the subjects had a mean frequency of more than once a day in Baseline, but in the Follow-ups, unlike the majority of subjects in the previous experiments who maintained improvements in their morning toothbrushing more effectively than at night, Neville's and Kirsty's difference score was higher at night than in the mornings.

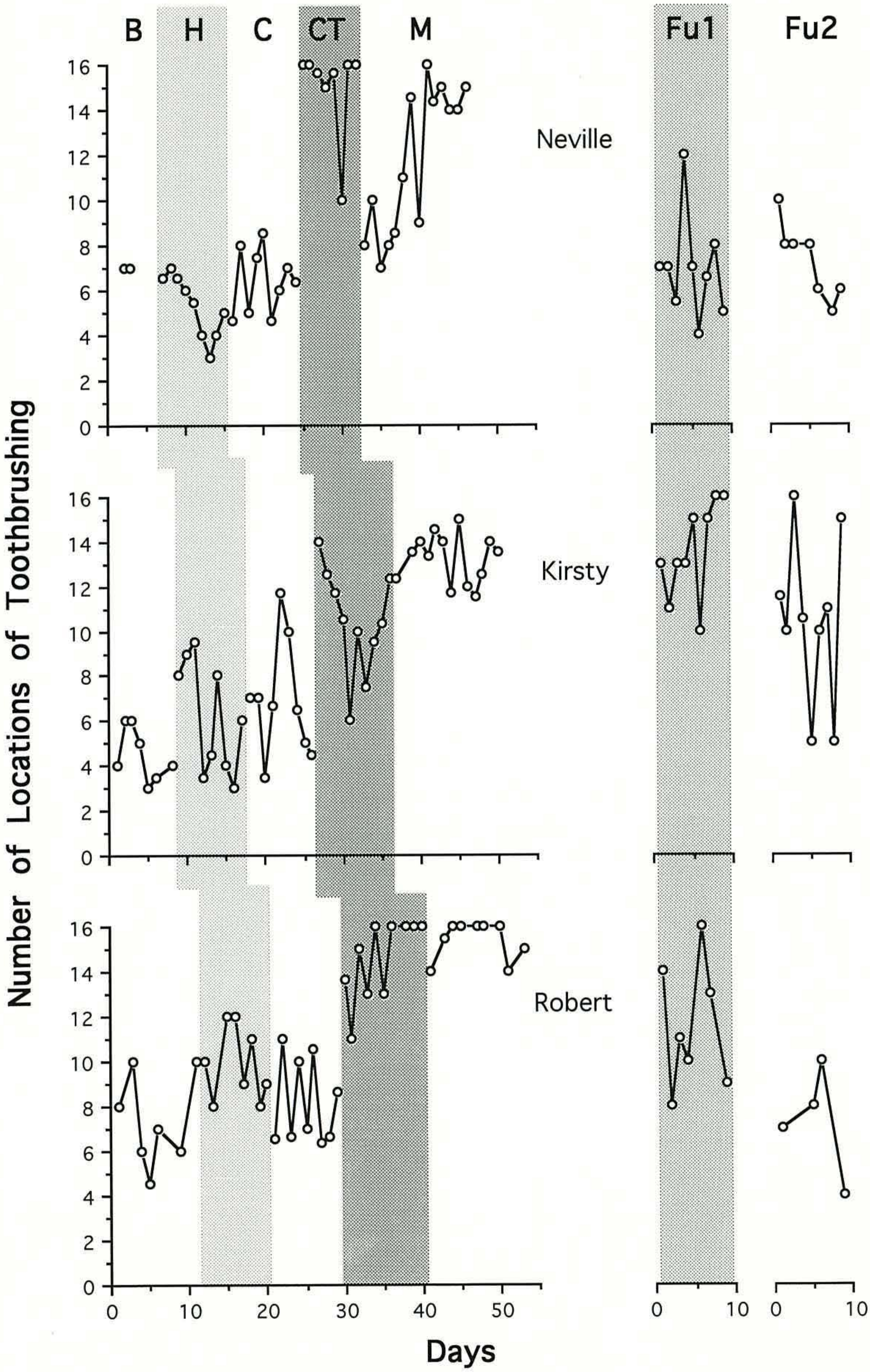
Locations of Toothbrushing

Figure 4.1.7 shows each subject's mean number of locations brushed per occasion on every day during Experiment 5, and Table 4.1.5 shows each subject's mean number of locations brushed per occasion in each condition.

Figure 4.1.7

Mean number of locations brushed per occasion per day for each subject during Baseline (B), Hygiene Tests (H), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). These data were calculated by adding together the number of locations brushed on each occasion each day, and dividing this sum by the frequency.

Figure 4.1.7



B
H
C
CT
M
Fu1
Fu2
Neville
Kirsty
Robert
Number of Locations of Toothbrushing
Days
0
2
4
6
8
10
12
14
16
0
10
20
30
40
50
0
10
0
10

TABLE 4.1.5

Mean Number of Locations Brushed per Occasion

Experiment 5

Each subject's mean number of locations brushed per occasion, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Hygiene Tests (H), Compliance Training (C), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions						
	B	**H**	**C**	**CT**	**M**	**Fu1**	**Fu2**
Neville							
Mean	7.00	5.28	6.41	15.04	11.74	6.89	7.29
Std D	0	1.37	1.44	2.07	3.23	2.28	1.70
N	2	9	9	8	14	9	7
Min	7.00	3.00	4.67	10.00	7.00	4.00	5.00
Max	7.00	7.00	8.50	16.00	16.00	12.00	10.00
Kirsty							
Mean	4.50	6.17	6.87	10.43	13.22	13.56	10.44
Std D	1.19	2.51	2.59	2.39	1.12	2.13	3.75
N	7	9	9	10	13	9	9
Min	3.00	3.00	3.50	6.00	11.50	10.00	5.00
Max	6.00	9.50	11.67	14.00	15.00	16.00	16.00
Robert							
Mean	7.36	9.88	8.15	14.57	15.39	11.57	7.25
Std D	2.10	1.64	1.91	1.79	0.86	2.88	2.50
N	7	8	9	10	9	7	4
Min	4.50	8.00	6.33	11.00	14.00	8.00	4.00
Max	10.00	12.00	11.00	16.00	16.00	16.00	10.00
Overall Mean	6.29	7.11	7.14	13.35	13.45	10.67	8.33

These figures show that the introduction of the Toothtutor resulted in uniform increases in the mean number of locations brushed per occasion per day by the subjects. These improvements were well sustained by all subjects in the Maintenance condition (M). Although Neville occasionally performed well in the two Follow-ups, his overall mean number of locations per occasion declined to levels similar to those in the first three conditions (B, H, and C). Kirsty, on the other hand, continued to brush many more locations on most occasions in both Follow-ups than she had done in Baseline (more than twice as many on average). Robert brushed well half of the time during Follow-up 1, and his mean per day was 13 locations or more on three occasions when the Toothtutor was present, but in Follow-up 2 when it was not, his performance was not distinguishable from that in Baseline.

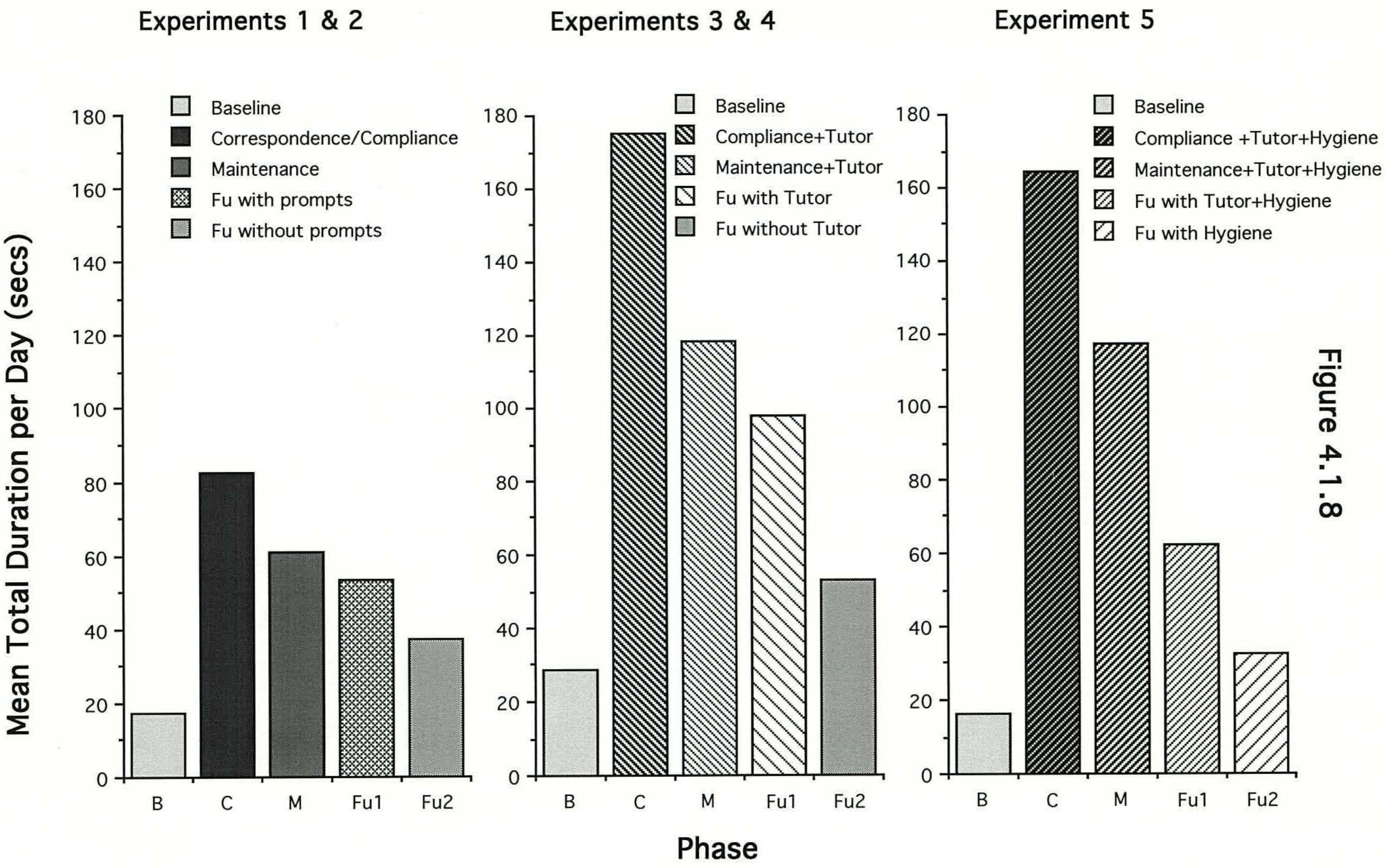
Inter-Experimental Comparison

Displayed in Figure 4.1.8 is the mean total duration per day in five conditions of the first pair of experiments (Expts. 1 & 2), five corresponding conditions of the second pair (Expts. 3 & 4) and five conditions of Experiment 5. Concern was expressed in Section 3.3 (General Results) of the previous chapter about the validity of comparing data from the first four experiments, especially because the Baseline mean total duration level in Experiments 3 and 4 (28.72 secs) was higher than that for Experiments 1 and 2. Figure 4.1.8 shows that the phase mean duration per day for Baseline in Experiment 5 (16.16 secs) was slightly lower than but very similar to that for Experiments 1 and 2 combined (17.34 secs). Table 4.1.6 shows that both the mean frequency and the mean duration per occasion across the 3 subjects in Experiment 5 were similar to the means across all subjects in Experiments 1 and 2.

The treatment effects when the Toothtutor was present (in Experiments 3, 4 and 5) were clearly far greater than when it was not (Experiments 1 and 2). During training (C) the mean total duration per day for the three subjects in Experiment 5 (164.06 secs) was similar to the mean total duration per day for the six subjects in Experiments 3 & 4 (175.30 secs), even though the Baseline level much was lower, and increased durations were no longer directly rewarded. Table 4.1.6 shows, however, that subjects in Experiment 5 tended to brush more frequently (all brushed on average more than twice a day), but for less time per occasion than subjects in Experiments 3 and 4. Nevertheless, in Experiment 5 there is no overlap in either frequency or duration levels between Baseline and the Compliance Training + Toothtutor condition (C). That is, in the Compliance Training + Toothtutor condition all three subjects brushed more frequently (minimum mean = 2.09 times per day) and for longer per occasion (minimum mean = 49.90 secs) than any of them had brushed in Baseline (maximum mean frequency = 1.00, maximum mean duration = 31.50 secs).

Figure 4.1.8

Mean total duration of toothbrushing per day for all subjects in each of four phases in Experiments 1 and 2 (left side), Baseline (B), Duration Correspondence/Compliance Training (C), Maintenance (M) and the two Follow-ups (Fu1 and Fu2); four phases in Experiments 3 and 4 (middle), Baseline (B), Compliance Training + Toothtutor (C), Maintenance (M) and the two Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it); and four phases in Experiment 5 (right side), Baseline (B), Hygiene Tests + Compliance Training + Toothtutor (C), Maintenance (M) and the two Follow-ups with hygiene tests (Fu1 - with the Toothtutor; Fu2 - without it). The data were calculated by totalling each subject's mean duration per session per day in each phase and dividing by the total number of subjects in each experiment or pair of experiments.



Experiments 1 & 2
Experiments 3 & 4
Experiment 5
Mean Total Duration per Day (secs)
Phase
B
C
M
Fu1
Fu2
Baseline
Correspondence/Compliance
Maintenance
Fu with prompts
Fu without prompts
Compliance+Tutor
Maintenance+Tutor
Fu with Tutor
Fu without Tutor
Compliance +Tutor+Hygiene
Maintenance+Tutor+Hygiene
Fu with Tutor+Hygiene
Fu with Hygiene

Figure 4.1.8

A comparison of the Baseline with the Maintenance and first Follow-up data indicates that higher mean durations were maintained when the Toothtutor was present (in Experiments 3, 4 and 5) than when it was not (in Experiments 1 and 2). A comparison of the Baseline and second Follow-up data reveals, however, that neither the frequency nor the durations of toothbrushing were better maintained in Experiments 3, 4 and 5, after the removal of the Toothtutor, than in Experiments 1 and 2, when the Toothtutor had never been introduced.

In Experiment 5, the combination of weekly hygiene tests and weekly pocket money, offered contingent upon brushing frequently and maintaining plaque scores above a criterion level, did not produce maintenance effects that were greatly different from those in the previous experiments. In fact, although the subjects in Experiment 5 maintained 'good' hygiene scores in the second Follow-up, and tended to brush (i) more frequently in this condition (mean = 1.22 times per day) than in Baseline (mean = 0.72), and (ii) more locations per occasion than in Baseline (Baseline mean = 6.29 locations; Follow-up 2 mean = 8.33 locations), their mean duration per occasion was slightly lower in Follow-up 2 (mean = 23.92 secs) than in Baseline (mean = 24.76 secs).

DISCUSSION

This experiment has demonstrated that parents can successfully administer a modified version of the behaviour change package that was developed in the previous experiments. These parents were asked to monitor the frequency of their childrens' toothbrushing, but were asked not to remain present when the children were brushing their teeth. The video camera evidence concerning the durations and number of locations brushed per toothbrushing event was *never* made known to the parents, and yet they were able to implement procedures that led to substantial improvements in their children's toothbrushing behaviour.

The modified version of the *Plaque Control Record* proved to be a quick and easy method of assessing dental hygiene, and the parents learned to apply it reliably on a model with very little tuition. In the Hygiene Tests condition when parents conducted the plaque assessments daily, but gave their children no feedback about their dental hygiene, all the children increased their frequency of toothbrushing, particularly at night immediately after the tests. This led to an average 153% increase in the total amount of time the children spent brushing their teeth each day compared to Baseline. In the next condition, Compliance Training, parents instructed their children that they should brush every part of all of their teeth and gums every morning and every night. Rewards were made dependent upon the children (i) brushing their teeth twice each day, and (ii) improving their dental hygiene (as measured using the *Plaque Control Record)* to a criterion level.

This procedure led to further increases in brushing frequency (both at night and in the mornings), and an average increase in total toothbrushing durations per day of 264% above Baseline. The children did not, however, increase the amount of time spent brushing their teeth each time they brushed, nor the number of locations that were brushed on each occasion. Only when the Toothtutor was introduced into the Compliance Training package was there a substantial increase in mean durations and number of locations brushed per occasion. In this condition children spent an average of 915% more time brushing their teeth each day than they had done in Baseline.

During the Compliance Training interventions in the current experiment, instructions were given at night after the hygiene tests, and to gain rewards the children were required to brush their teeth the following morning, and the following evening before the next hygiene test. In other words the "temporal gaps" were quite different to those in previous experiments (cf. Ch. 2 Sect. 3 - Expt. 1 Introduction and Discussion), because in this experiment the instructions were given 12 hours or more before the time for the first brushing event (in the morning), and almost 24 hours before the time for the second brushing event (in the evening), whilst feedback and consequences for behaviour were delivered almost immediately after the evening brushing. The interventions were effective despite this change of arrangement. In fact, the children who participated in this experiment brushed more frequently during training than any of the subjects in previous experiments, and they all spent more time brushing in the evenings than in the mornings. Although this could possibly have been because rewards were delivered soon after the evening brushing, a more likely cause was simply the introduction of the hygiene test procedure, since the frequency of evening brushing was increased even before the introduction of the Compliance Training contingency. During Compliance Training, however, the subjects often brushed twice at night, once before the hygiene test (to fulfil the contingency requirements), and once after it (as was their tendency in the previous condition - Hygiene Tests). Part of the reason for this was that, although instructed otherwise, parents often prompted their children to brush their teeth *after* the hygiene tests. They did this to ensure that all of the disclosing agent (erythrosine) used for the hygiene tests was removed from their children's mouths, since occasionally, when children went to bed without first brushing their teeth, they woke up with stained pyjamas and bed linen. This became less of a problem as the children's dental hygiene improved, because with less plaque and debris in the mouth to absorb the erythrosine, most of it was rinsed out immediately, and would not come into contact with the bed clothes.

Although the current procedures did not lead to an overall improvement in maintenance effects compared to previous studies, they may have been responsible for the different pattern of maintained behaviour observed during the Follow-ups in this experiment. As previously mentioned, the majority of subjects in the first four experiments maintained improvements in performance more effectively in the morning than at night, but probably as a result of the hygiene tests being administered in evenings, the opposite was true of the subjects in Experiment 5.

In summary, rewards delivered dependent on subjects increasing hygiene test scores, and brushing twice per day, once in the morning and once in the evening *before* the test, resulted in increases in subjects' frequency and total daily durations of toothbrushing. The introduction of the Toothtutor led to further increases in total durations. Increases in the mean duration and number of locations of toothbrushing per occasion appeared to be more dependent on the presence of the Toothtutor than in Experiment 3 when increasing durations were rewarded directly. The results of the current experiment indicate that the children's dental hygiene was improved by the intervention procedures, and that the improvements in dental hygiene were related to the recorded increases in the frequency, durations and number of locations of toothbrushing. Pocket money appears to reinforce changes in toothbrushing behaviour during the training conditions as effectively as the gifts used in the previous experiments. Although the dental hygiene scores remained high during the two-month Follow-ups, the procedures used in this experiment, which included continuing to make pocket money contingent upon the children brushing frequently, and maintaining hygiene scores above a criterion level, did not maintain the improved toothbrushing behaviour any more successfully than the procedures of previous experiments.

4.2 EXPERIMENT 6

The main objectives of this experiment were (i) to provide further evidence about the efficacy of the modified Compliance Training package, developed in Experiment 5, that did not depend on feedback from video recordings, (ii) to examine the effects of condensing the training package (i.e. reducing the number of intervention conditions), and (iii) to investigate the possibility of refining the procedures to gain further improvements in treatment and maintenance effects.

In this experiment, after Baseline and the Hygiene Tests condition, the Compliance Training contingency and the Toothtutor were introduced simultaneously in the same condition, rather than sequentially in two distinct conditions as in Experiments 3 and 5. Gifts were used as the rewards in the contingency, and as in Experiments 1 - 4 these were faded out during the Maintenance condition, whilst attempts were made to introduce more natural reinforcers (see Chapter 2 Section 2 - General Method).

Another difference to Experiment 5 was that the current procedure required that parents explain the meaning and relevance of the hygiene test procedure to their children on the first day of the Compliance Training condition. After each hygiene test throughout this, and all following conditions, the children were told their hygiene scores, and these were written on the calendars which were kept in the bathrooms. Providing the subjects with a quantification of the consequences of their toothbrushing behaviour may act as an additional reinforcer for "good" brushing behaviour, and therefore lead to greater improvements during intensive training, and better maintenance when material rewards were no longer made available.

It may be the case that one reason why the improved toothbrushing behaviour was not better maintained in Experiment 5 was that it was too easy for subjects to maintain high plaque test scores. They did not need to brush frequently or for very long in order to keep their dental hygiene at the criterion level. For this reason, parents of subjects in the current experiment were taught to make finer discriminations of the presence of plaque on each tooth surface than the parents of the children who participated in Experiment 5. In other words, it was made less likely that a tooth surface scored as clean by parents of subjects in Experiment 5 would also be scored as clean by parents of subjects in Experiment 6.

An attempt was made in Experiment 6 to eliminate a potentially confounding variable that was present in the previous study. The importance of not prompting toothbrushing, particularly after the hygiene tests, was strongly emphasized to the parents of subjects who participated in this experiment.

METHOD

PARTICIPANTS

(a) Subjects

Two boys (John and Alun) and a girl (Linda) participated as subjects. Their mean age was 5 years 5 months, which is somewhat younger than the average age of subjects in previous experiments (see Table 3.2.1 for complete subject and sibling details).

(b) Parents

In all cases the subject's mother implemented the procedures. Alun and Linda both lived in single parent families.

SETTINGS AND MATERIALS

(a) Recording

The modified mirror cabinets introduced for Experiments 3 and 4, with horizontal strip lights, were installed in the family bathrooms for this and all subsequent experiments.

(b) Rewards

The token reinforcement system implemented in Experiments 1-4, with gifts chosen from a catalogue as rewards, was used again in this and all subsequent experiments unless otherwise stated.

TABLE 4.2.1

AGE OF SUBJECTS AND THEIR SIBLINGS

EXPERIMENT 6

Subject	Age at start	Number of Siblings	Age of Siblings
John	5 yrs 7 mths	2	17 & 14 yrs
Alun	5 yrs 5 mths	1	3 yrs
Linda	5 yrs 2 mths	0	-

Mean age of subjects = 5 yrs 5 mths

Dependent Variables and Recording

(a) Target Behaviours

The dependent variables were: (i) toothbrushing frequency, (ii) toothbrushing duration, (iii) the number of dentition locations brushed during each session, and (iv) in all conditions following Baseline, an index of the level of plaque and dental debris adhering to the teeth (dental hygiene). As in Experiment 5, parents assessed dental hygiene using a modified version of the Plaque Control Record.

(b) Reliability

A second observer independently measured toothbrushing durations and number of locations brushed from 20% of the recorded toothbrushing occurrences. The overall agreement between the two observers for duration and number of locations, calculated using the Frequency Ratio method, was 98.3% and 98.2% respectively. For John agreement was 99.5% for duration and 99.7% for locations; for Alun it was 97.2% and 97.0% respectively; for Linda it was 98.1% and 97.8%. Correlations between the observers' measures were: overall, 0.992 and 0.833; for John, 0.995 and 0.722; Alun, 0.982 and 0.806; and Linda, 0.998 and 0.972.

As in Experiment 5, the reliability of the parents' hygiene scores was not assessed directly. Instead, each parent was trained to reliably score a model's plaque levels (see Experiment 5 for details). Training continued until agreement between the instructor's and the parents' hygiene scores was consistently greater than 90%. Parents' ability to conduct the hygiene test, as instructed, was assessed again at the end of the Maintenance phase and between the two Follow-up conditions. Agreement during these checks never fell to below 90%.

EXPERIMENTAL DESIGN

Baselines in this experiment were six days (John), nine days (Alun), and twelve days (Linda). After baseline all of the subjects were exposed to the following sequence of three intervention conditions:

(1) Hygiene Tests

(2) Hygiene Tests + Compliance Training + Toothtutor

(3) Maintenance of Compliance.

PROCEDURE

Hygiene Tests

The procedure for this condition was almost identical to that for Experiment 5, but extra measures were taken to ensure that parents did not prompt their children to brush their teeth in the evenings after the hygiene tests, or at any other time during this, or any subsequent conditions.

Hygiene Tests + Compliance Training + Toothtutor

The Toothtutor device and the compliance contingency were introduced simultaneously. The procedure was similar to that in Experiment 5 except that the material rewards were toys, books, and games chosen by the parents, and these were given daily (rather than pocket money given at the end of the week). The children were told their hygiene scores after each hygiene test throughout this condition, and until the end of the experiment, and to enhance their salience the scores were written on the calendars which were kept in the bathrooms.

Maintenance of Compliance

The instructions and opportunities for gaining material reward were systematically faded. Initially the parents conducted the first hygiene test on the second day, and wrote the hygiene score on the calendar as before. If the subject had brushed frequently and maintained their hygiene score above criterion, three days passed before the next assessment. If the frequency and hygiene score remained above criterion, then assessments were reduced to once a week on randomly assigned days. The subjects received feedback and rewards only on days when their dental hygiene was assessed.

Follow-up

During the eight weeks between the Maintenance condition and the first Follow-up phase, the Toothtutors were left in place, hygiene tests were conducted weekly, and parents continued to implement the token system, but no material rewards were given to the subjects.

In the first Follow-up toothbrushing performance was recorded for nine days whilst the Tutors were still in place. After this the Tutors were removed, and two weeks later, in the second Follow-up, the children's toothbrushing behaviour was examined again for a further nine days. Hygiene tests continued to be conducted once a week, and the same feedback and token system (without material rewards) was operative throughout.

RESULTS

Dental Hygiene

Figure 4.2.1 shows that the hygiene test scores given by parents varied within and between subjects in the absence of a contingency during the second phase of the experiment (H). John was given two high scores in the middle of this condition, but nine of his eleven scores ranged between 6 and 13 clean surfaces. Alun was consistently given scores (range, 20 - 30) that were higher than the other two subjects'. Linda, whose hygiene score was lowest at the beginning the Hygiene Tests condition, increased her score from 3 on the first day to 20 on the last. All three subjects increased their hygiene scores after the introduction of the Compliance Training contingency and the Toothtutor in the next condition (CT), but as in the previous phase, John's performance was least consistent (range, 9 - 22) and Linda's scores increased most rapidly (from 22 on the first day to 33 on the last). The subjects all maintained high dental hygiene scores throughout the Maintenance condition (M), the Follow-ups (Fu1 & Fu2) and the intervening periods (N1 & N2).

Frequency of Toothbrushing

Figure 4.2.2 and Table 4.2.2 show that John brushed his teeth once a day throughout Baseline, and Alun brushed twice a day on all but one occasion. Linda brushed three times a day for the first two days of Baseline, indicating that perhaps the seven day Prebaseline phase was not quite sufficient to allow her to get over the novelty of the bathroom cabinet, because for the rest of Baseline Linda's frequency fluctuated between once and twice a day.

Figure 4.2.1

The Hygiene Test scores supplied by each subject's parents during each of the five experimental phases of the study, Hygiene Tests (H), Compliance Training + Toothtutor (CT), Maintenance (M) and Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it), the 8 week period between Maintenance and the first Follow-up (N1), and the 2 week period between the first and second Follow-ups (N2).

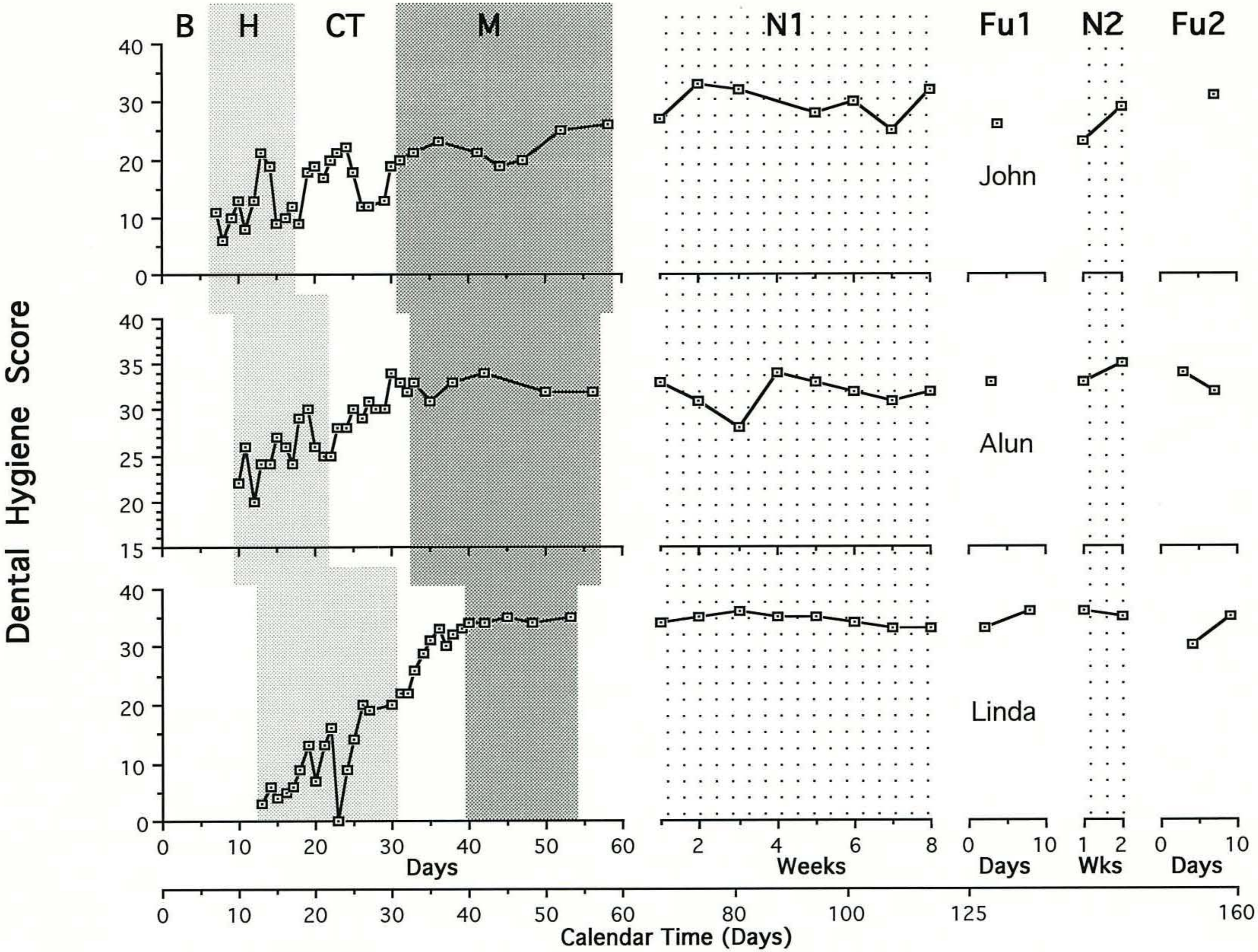

B
H
CT
M
N1
Fu1
N2
Fu2
Dental Hygiene Score
John
Alun
Linda
Days
Weeks
Days
Wks
Days
Calendar Time (Days)

Figure 4.2.1

Figure 4.2.2

Frequency of toothbrushing per day for each subject during each experimental phase: Baseline (B), Hygiene Tests (H), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Figure 4.2.2

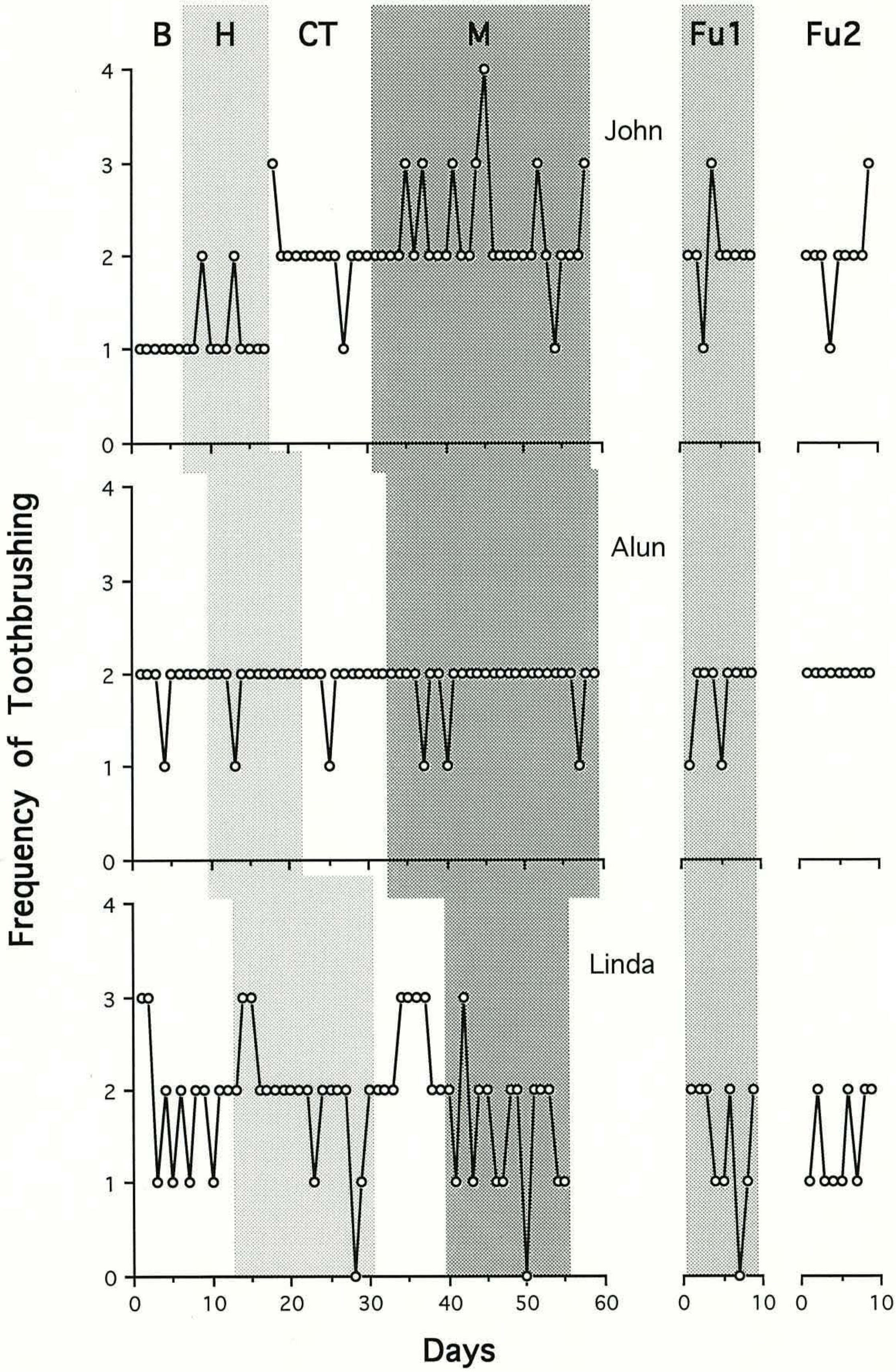

B
H
CT
M
Fu1
Fu2
John
Alun
Linda
Frequency of Toothbrushing
Days
0
1
2
3
4
0
10
20
30
40
50
60
0
10
0
10

TABLE 4.2.2

Mean Frequency of Toothbrushing

Experiment 6

Each subject's frequency of toothbrushing per day, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Hygiene Tests (H), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions					
	B	**H**	**CT**	**M**	**Fu1**	**Fu2**
John						
Mean	1.00	1.18	2.00	2.25	2.00	2.00
Std D	0	0.41	0.41	0.59	0.50	0.50
N	6	11	13	28	9	9
Range	1 - 1	1 - 2	1 - 3	1 - 4	1 - 3	1 - 3
Alun						
Mean	1.89	1.92	1.91	1.89	1.78	2.00
Std D	0.33	0.29	0.30	0.32	0.44	0
N	9	12	11	27	9	9
Range	1 - 2	1 - 2	1 - 2	1 - 2	1 - 2	2 - 2
Linda						
Mean	1.83	1.89	2.44	1.56	1.44	1.44
Std D	0.72	0.68	0.53	0.72	0.73	0.53
N	12	18	9	32	9	9
Range	1 - 3	0 - 3	2 - 3	0 - 3	0 - 2	1 - 2
Overall Mean	1.57	1.66	2.12	1.90	1.74	1.81

Frequency of Toothbrushing was not much altered after the introduction of the Hygiene Tests condition (H). John brushed twice on only two days, but otherwise brushed consistently once a day as he had done in Baseline. Alun's performance was completely unchanged as was Linda's, who again brushed three times a day twice at the beginning of the phase. John and Linda increased their frequency of toothbrushing after the introduction of the Compliance Training contingencies and the Toothtutor in the next condition (CT). John brushed even more frequently during the Maintenance condition, and his mean per day was 2.00 in both Follow-up conditions, whereas Linda's mean frequency per day was reduced to a little below her Baseline level in the last three conditions (M, Fu1 & Fu2).

Mean Duration of Toothbrushing per Occasion

It can be seen from Figure 4.2.3, and Table 4.2.3, that all three subjects spent considerably longer brushing their teeth on every occasion that they brushed during the Compliance Training + Toothtutor condition (CT) than they had done at any time during Baseline (B), or the Hygiene Tests condition (H). John and Alun maintained consistently high durations per occasion throughout the Maintenance condition (M), and their means for this phase were 4.8 and 3 times their Baseline levels respectively. Linda's durations were a little more erratic, but her mean duration per occasion for the Maintenance condition was 4.6 times that in Baseline.

Figure 4.2.3

Mean duration of toothbrushing per occasion per day for each subject during Baseline (B), Hygiene Tests (H), Compliance Training + Toothtutor (CT), Maintenance (M) and both two month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). These data were calculated by totalling all the recorded durations each day, and dividing this sum by the daily frequency.

Figure 4.2.3

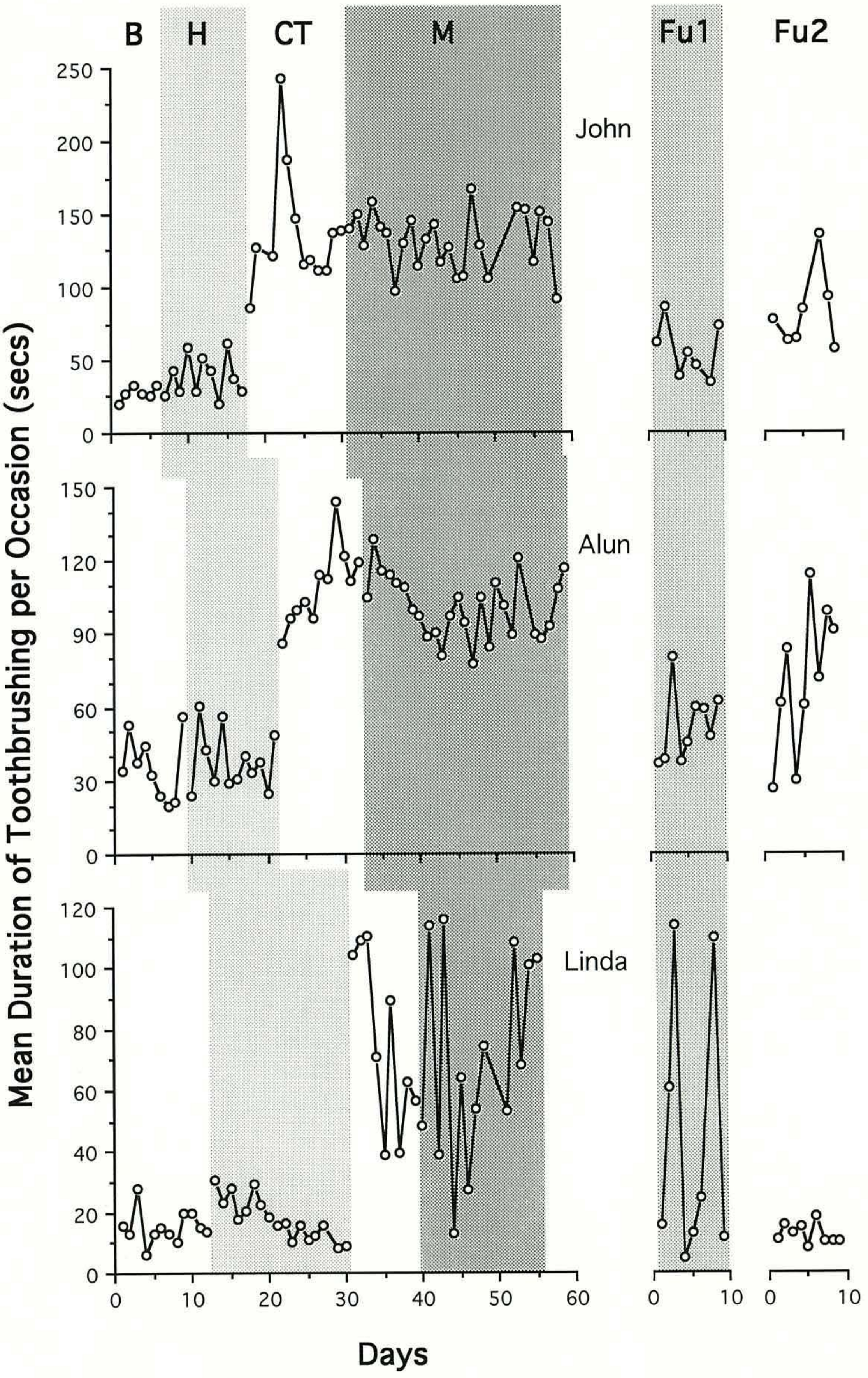

B
H
CT
M
Fu1
Fu2
John
Alun
Linda
Mean Duration of Toothbrushing per Occasion (secs)
Days
250
200
150
100
50
0
150
120
90
60
30
0
120
100
80
60
40
20
0
0
10
20
30
40
50
60
0
10
0
10

TABLE 4.2.3

Mean Duration of Toothbrushing per Occasion

Experiment 6

Each subject's mean duration of toothbrushing per occasion per day, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Hygiene Tests (H), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions					
	B	**H**	**CT**	**M**	**Fu1**	**Fu2**
John						
Mean	27.50	38.82	136.94	131.56	56.21	81.86
Std D	4.97	14.19	41.45	20.26	18.43	27.14
N	6	11	12	25	7	7
Min	20.00	20.00	85.33	92.00	35.00	56.50
Max	33.00	62.00	242.50	167.00	85.00	136.00
Alun						
Mean	35.72	38.17	109.55	100.79	51.83	70.89
Std D	13.08	11.99	15.76	12.97	14.70	29.85
N	9	12	11	26	9	9
Min	20.00	23.50	86.00	77.50	37.00	26.50
Max	56.00	60.50	144.00	128.50	80.50	114.50
Linda						
Mean	15.21	17.88	75.67	70.26	44.38	12.39
Std D	5.56	7.01	28.63	33.64	45.11	3.36
N	12	17	9	14	8	9
Min	6.00	8.00	38.67	13.00	5.00	8.00
Max	28.00	30.50	110.50	116.00	114.00	18.50
Overall Mean	26.14	31.62	107.39	100.87	50.81	55.05

John's mean duration per occasion on every day of recording in both Follow-ups (Fu1 & Fu2) was greater than on any occasion in Baseline (see Table 4.2.3). Like John, Alun tended to spend more time brushing his teeth in the second Follow-up, after the removal of the Toothtutor, than he did in the first Follow-up, but in both conditions his overall mean was well above his Baseline mean. Because Linda used the Toothtutor to guide her behaviour only periodically during the first Follow-up, her performance was extremely variable, but her overall mean for this phase was almost 3 times her Baseline level. Linda's durations per occasion were stable and low during the second Follow-up.

Total Duration of Toothbrushing per Day

Figure 4.2.4 shows that, on several days after the introduction of the Hygiene Tests condition (H), John spent more time brushing his teeth than he had done in Baseline. It can be seen from the right hand side of Figure 4.2.5, and from Table 4.2.4, that the total durations of the two other subjects were not much altered by this procedure, but that after the introduction of the Compliance Training + Toothtutor condition (CT) however, all three subjects increased their total duration levels considerably. John's mean total duration per day (271.75 secs.) was 888% above the Baseline level (27.50 secs.), Alun's mean had increased by 209%, and Linda's by 523%.

The left side of Figure 4.2.5 shows why the percentage increases over Baseline were so much greater for John than for Alun. Alun's frequency of toothbrushing did not increase during the Compliance Training + Toothtutor condition, because he brushed his teeth the criterion number of times a day (twice) on most days throughout the study. John brushed his teeth on every single evening, but during Baseline he did not brush at all in the mornings. In the Hygiene Tests condition he brushed on only 2 mornings out of 11, but in the next, and all following conditions, he brushed morning and night almost every day. In other words, John had doubled his frequency whilst Alun's frequency remained stable (see also Figure 4.2.1 and Table 4.2.2).

John's total duration per day remained high every day during the Maintenance condition (M), and Alun's behaviour was also very similar to that in the previous condition. Linda's frequency of toothbrushing declined to below its Baseline level, and so her total durations per day were also reduced, but because of her much increased durations per occasion (see Figure 4.2.2 and Table 4.2.3), Linda's mean total duration per day was still 258% above Baseline. All three subjects spent longer brushing on average during the first Follow-up than they had done in Baseline. John spent less time after the Tutor had been removed in the second Follow-up, but his mean duration per session in this phase was still 244% higher than the Baseline. Alun tended to spend longer in Follow-up 2 than in Follow-up 1, whereas Linda's mean total duration was lower in the final condition than it was in Baseline.

Figure 4.2.4

Total duration of toothbrushing per day for each of the subjects during Baseline (B), Hygiene Tests (H), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). Data for this figure were calculated by totalling known durations of all toothbrushing events that occurred on each day.

Figure 4.2.4

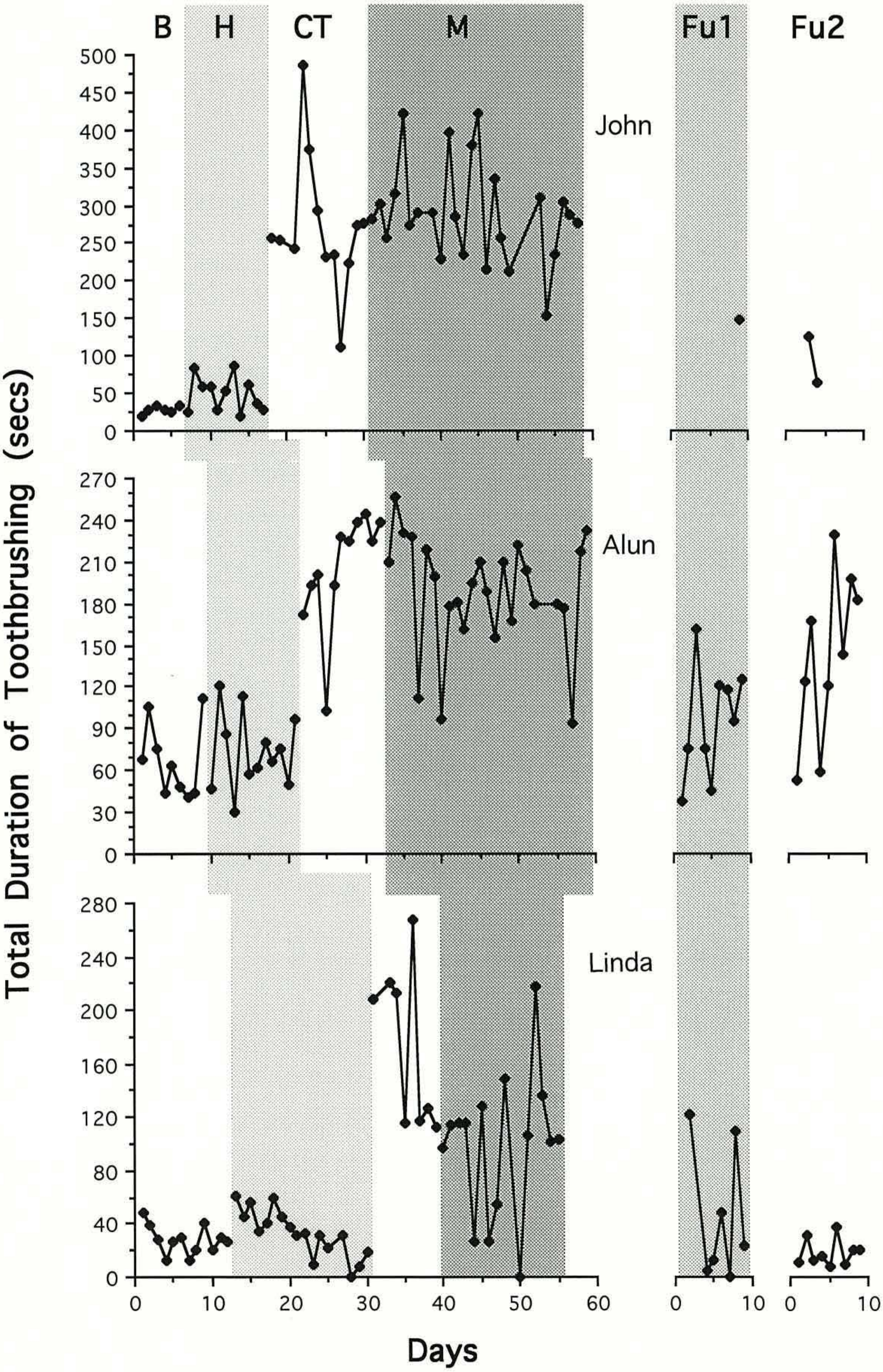
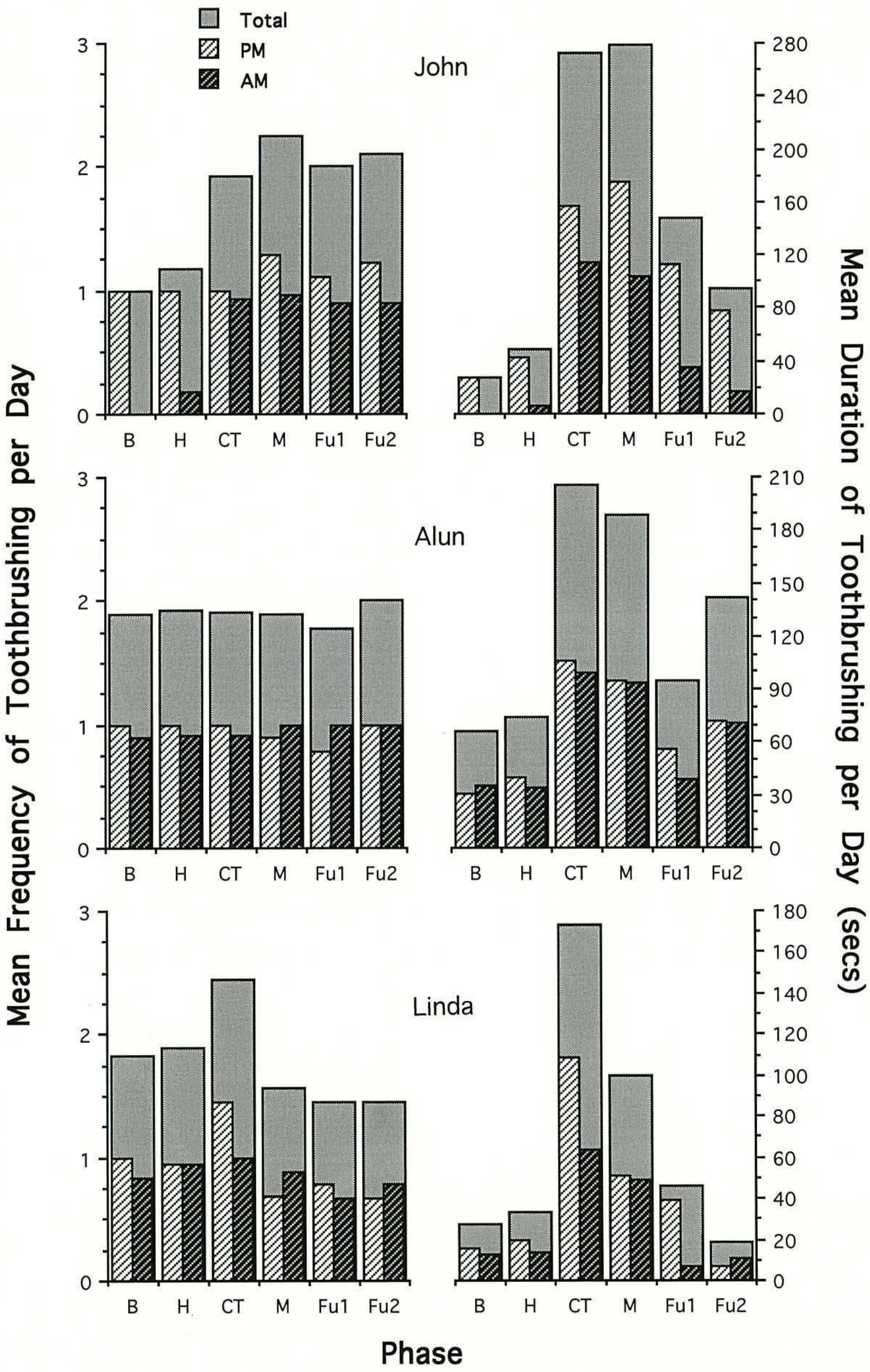

B
H
CT
M
Fu1
Fu2
John
Alun
Linda
Total Duration of Toothbrushing (secs)
Days
500
450
400
350
300
250
200
150
100
50
0
270
240
210
180
150
120
90
60
30
0
280
240
200
160
120
80
40
0
0
10
20
30
40
50
60
0
10
0
10

Figure 4.2.5

The mean frequency of toothbrushing per day (left side) and the mean total duration of brushing per day (right side) for each subject in each of the phases. The means for evening (light diagonal line shading) and morning sessions (dark diagonal line shading) in each phase are also shown. Data for the frequency graph (left side) were calculated by totalling the number of brushing events that occurred at night and in the morning, and dividing by the total number of days in the phase. Data for the duration graph were calculated by totalling each subject's known durations at night and in the morning in each phase and dividing by the total number of sessions (of known duration) in the phase.

Figure 4.2.5



Total
PM
AM
John
Alun
Linda
Mean Frequency of Toothbrushing per Day
Mean Duration of Toothbrushing per Day (secs)
B
H
CT
M
Fu1
Fu2
Phase

TABLE 4.2.4

Mean Total Duration Difference Scores

Experiment 6

The percentage difference between each subject's Baseline mean total duration per day and his/her mean total duration per day in all subsequent phases: Baseline (B), Hygiene Tests (H), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Sessions	Experimental Conditions				
	H	**CT**	**M**	**Fu1**	**Fu2**
John					
PM	55%	472%	538%	307%	184%
AM	555%	11358%	10232%	3400%	1550%
Total	**79%**	**888%**	**913%**	**435%**	**244%**
Alun					
PM	27%	239%	201%	78%	128%
AM	- 4%	182%	166%	10%	99%
Total	**11%**	**209%**	**182%**	**42%**	**113%**
Linda					
PM	26%	617%	234%	161%	- 52%
AM	12%	409%	287%	- 49%	- 11%
Total	**20%**	**523%**	**258%**	**66%**	**- 34%**
Overall Mean	**37%**	**540%**	**451%**	**181%**	**108%**

It should be noted that the recording equipment installed at John's house did not function well during the two Follow-up conditions. It was only possible to accurately rate durations of toothbrushing on 8 out of the 18 occasions that John brushed his teeth during the first Follow-up, and only two of these occasions were on the same day, thus accounting for the single data point for Follow-up 1 in Figure 4.2.4. Only 9 out of 18 toothbrushing events could be rated in Follow-up 2, and only four of these were on the same day (so there are 2 data points for this condition in Figure 4.2.4). However, all the available data were used for the calculations required to produce Figure 4.2.5 and Table 4.2.4.

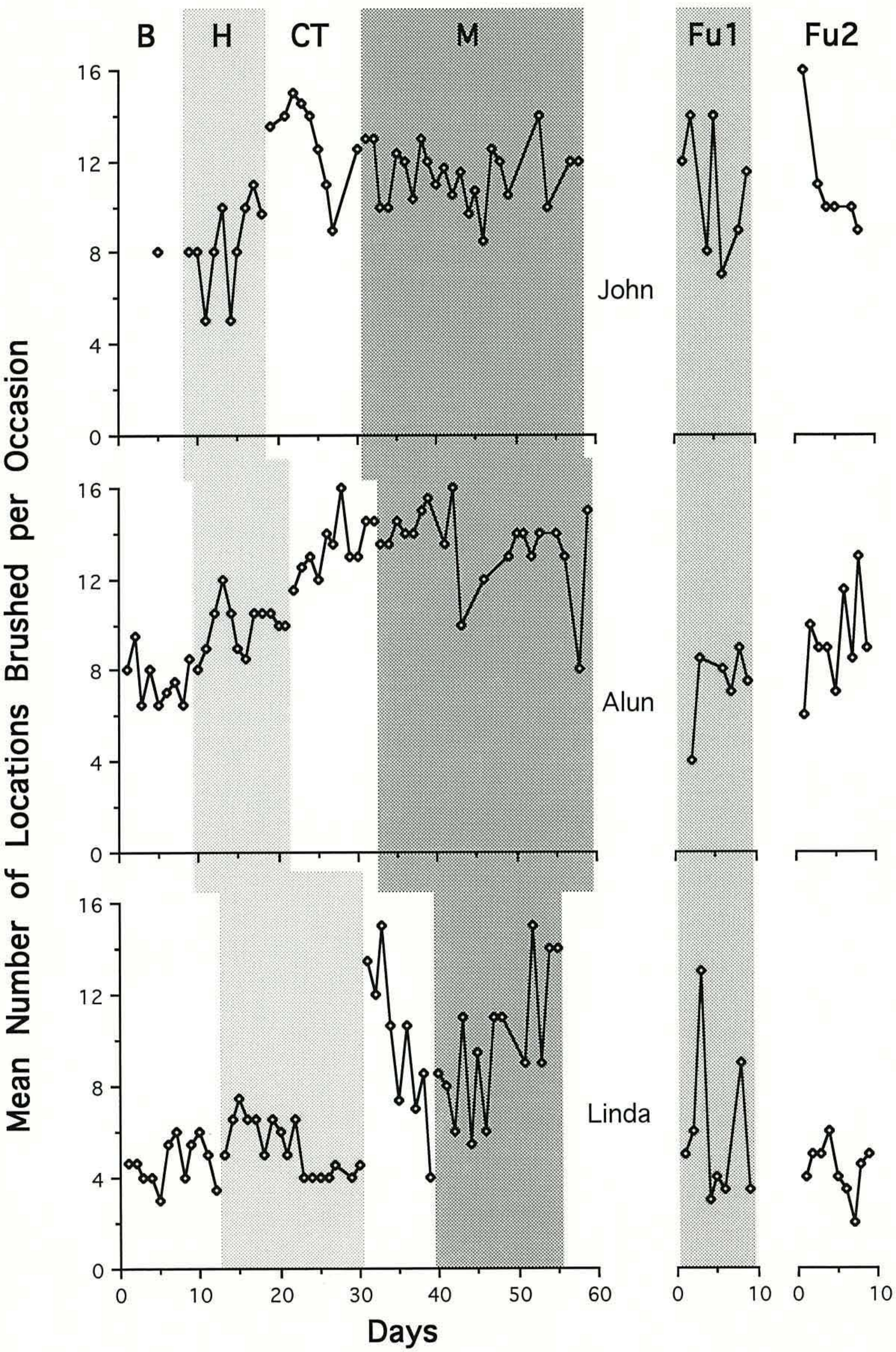
Locations of Toothbrushing

Figure 4.2.6 and Table 4.2.5 show that, although the mean number of locations brushed by the subjects per occasion per day was not much changed by the introduction of the Hygiene Tests procedure (H), there were immediate increases in all cases after the introduction of Compliance Training and the Toothtutor, and these increases were sustained throughout this condition (CT) and Maintenance (M). Performance during the two Follow-ups (Fu1 & Fu2) was variable, occasionally better than Baseline, but generally not much different.

Figure 4.2.6

Mean number of locations brushed per occasion per day for each subject during Baseline (B), Hygiene Tests (H), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). These data were calculated by adding together the number of locations brushed on each occasion each day, and dividing this sum by the frequency.

Figure 4.2.6



B
H
CT
M
Fu1
Fu2
John
Alun
Linda
Mean Number of Locations Brushed per Occasion
16
12
8
4
0
0
10
20
30
40
50
60
0
10
0
10
Days

TABLE 4.2.5

Mean Number of Locations of Toothbrushing per Occasion

Experiment 6

Each subject's mean number of locations of toothbrushing per occasion per day, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Hygiene Tests (H), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions					
	B	**H**	**CT**	**M**	**Fu1**	**Fu2**
John						
Mean	*	8.11	12.57	11.40	10.79	11.00
Std D	*	2.09	2.06	1.33	2.83	2.53
N	1	9	10	23	7	6
Min	*	5.00	9.00	8.50	7.00	9.00
Max	*	11.00	15.00	14.00	14.00	16.00
Alun						
Mean	7.56	9.92	13.41	13.48	7.33	9.22
Std D	1.04	1.10	1.28	1.82	1.78	2.12
N	9	12	11	20	6	9
Min	6.50	8.00	11.50	8.00	4.00	6.00
Max	9.50	12.00	16.00	16.00	9.00	13.00
Linda						
Mean	4.65	5.29	9.85	9.82	5.88	4.33
Std D	0.98	1.19	3.47	3.04	3.47	1.15
N	12	17	9	14	8	9
Min	3.00	4.00	4.00	5.50	3.00	2.00
Max	6.00	7.50	15.00	15.00	13.00	6.00
Overall Mean	6.11	7.77	11.94	11.57	8.00	8.18

* Indicates that there are insufficient data.

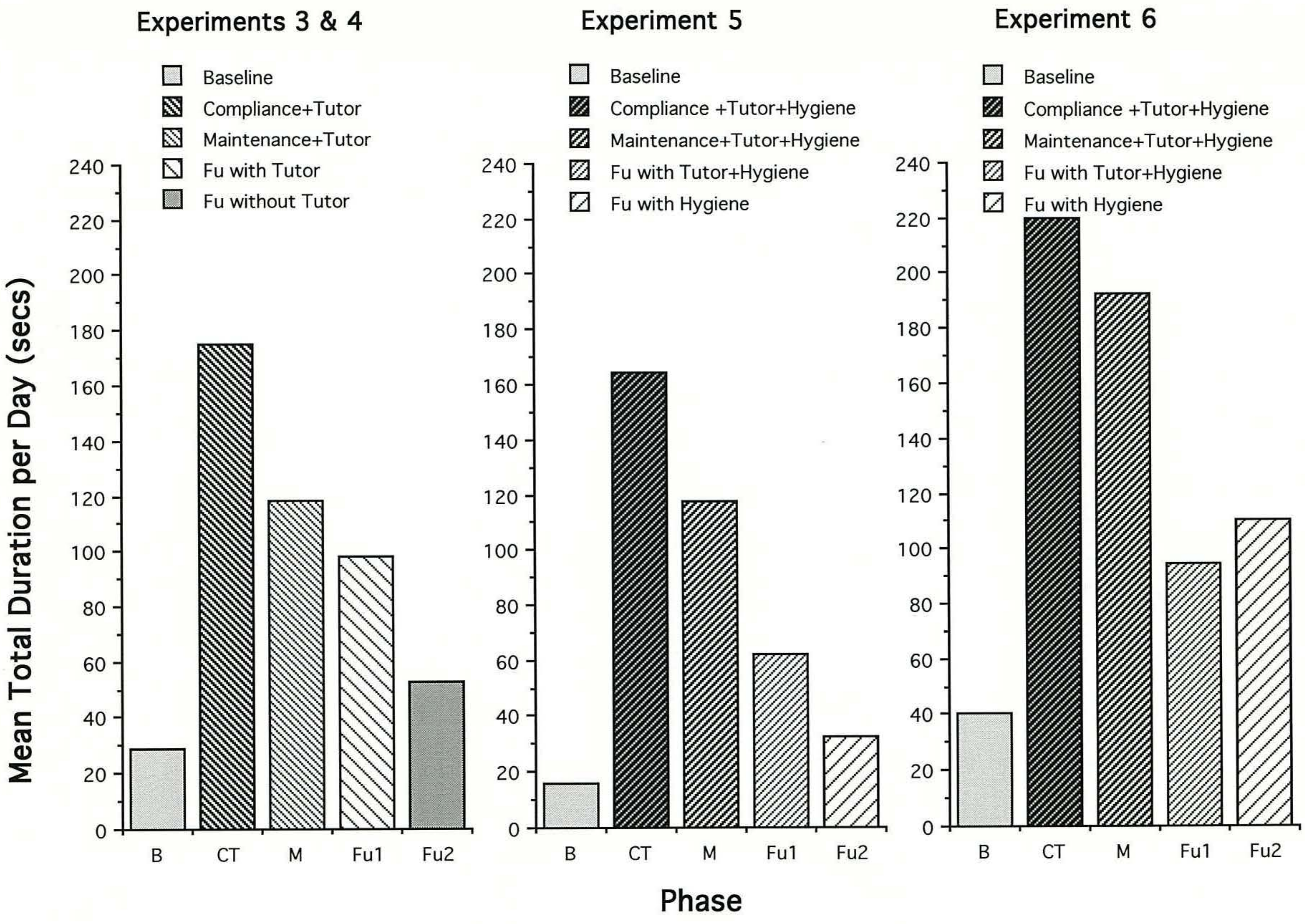
Inter-Experimental Comparison

Figure 4.2.7 compares the mean total duration data from five conditions in Experiments 3&4, with data from Experiment 5 and from Experiment 6. The Baseline mean total duration per day for the three subjects in Experiment 6 (40.60 secs) is greater than the Baseline means for the subjects in the three previous experiments. Table 4.2.6 shows that this was due mainly to a higher mean frequency of toothbrushing rather than a higher mean duration per occasion. That is, none of the subjects in Experiment 6 brushed less than once a day on average, but their mean duration per occasion (26.14 secs) was less than that for the six subjects in Experiments 3&4 (29.16 secs).

Figure 4.2.7 shows that the mean total duration per day in the Compliance Training + Toothtutor condition of Experiment 6 (216.62 secs) was considerably higher than the means for the corresponding condition in the previous experiments (175.30 secs. in Experiments 3&4, 164.06 secs. in Experiment 5). Table 4.2.6 reveals that it was not that the subjects in Experiment 6 brushed more frequently in this condition than the other subjects, but that they brushed for much longer per occasion. These subjects brushed twice a day on most days, and for almost a full two minutes on every occasion that they brushed. In other words, they were brushing at close to the optimum level recommended by dentists that was taken as the goal of the current research project.

Figure 4.2.7

Mean total duration of toothbrushing per day for all subjects in each of five phases, Baseline (B), Compliance Training + Toothtutor (CT), Maintenance (M) and the two Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it) in Experiments 3 and 4 (left side), Experiment 5 (middle), and Experiment 6 (right side). The data were calculated by totalling each subject's mean total duration per day in each phase and dividing by the total number of subjects in each experiment or pair of experiments.



Experiments 3 & 4
Baseline
Compliance+Tutor
Maintenance+Tutor
Fu with Tutor
Fu without Tutor
Experiment 5
Baseline
Compliance +Tutor+Hygiene
Maintenance+Tutor+Hygiene
Fu with Tutor+Hygiene
Fu with Hygiene
Experiment 6
Baseline
Compliance +Tutor+Hygiene
Maintenance+Tutor+Hygiene
Fu with Tutor+Hygiene
Fu with Hygiene
Mean Total Duration per Day (secs)
0
20
40
60
80
100
120
140
160
180
200
220
240
B
CT
M
Fu1
Fu2
Phase

Figure 4.2.7

TABLE 4.2.6

Mean Frequency and Duration per Occasion

Experiments 3&4, 5 and 6.

The mean frequency and mean duration of toothbrushing per occasion per day in 5 conditions of Experiments 3 & 4 combined, Experiment 5, and Experiment 6: Baseline (B), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). The minimum and maximum values of subject means are also shown.

Experimental Details and Measures		Experimental Conditions				
		B	**CT**	**M**	**Fu1**	**Fu2**
Expts. 3&4 (N=6 Ss)						
Frequency -	Mean	**1.25**	**1.99**	**1.70**	**1.56**	**1.56**
	Min	0.33	1.80	1.35	0.56	0.89
	Max	2.00	2.20	2.00	2.11	1.89
Duration -	Mean	**29.16**	**88.98**	**71.45**	**64.70**	**34.35**
	Min	11.31	59.57	35.62	32.83	16.69
	Max	52.50	106.61	107.02	100.40	44.33
Expt. 5+ (N = 3 Ss)						
Frequency -	Mean	**0.72**	**2.21**	**1.62**	**1.41**	**1.22**
	Min	0.33	2.09	0.71	0.89	0.44
	Max	1.00	2.30	2.15	1.89	1.89
Duration -	Mean	**24.76**	**74.26**	**80.98**	**41.32**	**23.92**
	Min	14.50	49.90	58.60	23.89	17.00
	Max	31.50	89.94	114.17	62.06	31.56
Expt. 6+ (N = 3 Ss)						
Frequency -	Mean	**1.57**	**2.12**	**1.90**	**1.74**	**1.81**
	Min	1.00	1.91	1.56	1.44	1.44
	Max	1.89	2.44	2.25	2.00	2.00
Duration -	Mean	**26.14**	**107.39**	**100.87**	**50.81**	**55.05**
	Min	15.21	75.67	70.26	44.38	12.39
	Max	35.72	136.94	131.56	56.21	81.86

+ Hygiene tests during conditions CT, M, Fu1 and Fu2.

It can be seen from Figure 4.2.7 and Table 4.2.6 that the performance of subjects in Experiment 6 during the second Follow-up, after the removal of the Toothtutor, was superior to that of subjects in the corresponding condition of the other three experiments that had included the Toothtutor in the procedures. The figures and tables presented earlier in this section show that two of the subjects (John and Alun) sustained both frequency and mean duration per occasion well in Follow-up 2, but that the performance of the other subject (Linda) declined much as that of the subjects in previous experiments.

DISCUSSION

This experiment has provided further evidence that a Compliance Training procedure, in which subjects are rewarded dependent on their frequency of toothbrushing and their hygiene test scores, can be implemented effectively by parents to improve the toothbrushing behaviour of their children. Introducing Compliance Training and the Toothtutor simultaneously in the same condition appears to have been as effective as introducing them sequentially (as in Experiments 3 and 5).

The extra measures taken to ensure that parents did not prompt their children to brush after the hygiene tests were generally effective. Only Linda's mother was ever observed prompting, and only Linda tended to brush after the hygiene tests during the Compliance Training + Toothtutor condition. Unlike the subjects in Experiment 5, John and Alun did not brush more than twice a day in this condition, but they did spend more time brushing per occasion than any of the subjects in any previous experiment, so that despite the lower average frequency, the mean total duration per day was much higher in Experiment 6 (219.75 secs) than in Experiment 5 (164.06 secs).

As shown by the high correlation between parents' scores and the instructors scores whenever reliability was checked on the model, parents were able to make the fine discriminations of the presence of plaque on each tooth surface that was required in this experiment. Although subjects who participated in Experiment 6 generally spent longer brushing their teeth than subjects in Experiment 5, their hygiene scores did not improve as rapidly, and with the exception of Linda, their scores did not ever reach the same high levels. This indicates that subjects in Experiment 6 may have needed to brush each tooth surface more thoroughly than subjects in Experiment 5, to have their parents score it as "clean", and one may speculate that this was an important factor determining the maintenance of higher durations in Experiment 6. This remains uncertain, however, because there were other important differences in procedure between Experiments 5 and 6: the relative contribution of each cannot be determined. For this same reason, the effects of using gifts rather then pocket money, and the effects of making the subjects more aware of their hygiene scores, also remain uncertain, and would need further investigation to clarify.

4.3 GENERAL DISCUSSION

Experiments 5 and 6 have shown that when children are exposed to procedures that (i) highlight the level of plaque and dental debris on the surfaces of teeth, (ii) reward children for brushing frequently and improving their dental hygiene, and (iii) include a stimulus control device, the Toothtutor, they will increase their frequency of toothbrushing, as well as the durations and number of locations that they brush on each occasion. The results indicate that the children's dental hygiene was improved by the experimental interventions, and that the improved hygiene was sustained in the two-month Follow-ups.

Higher durations during training, and better maintenance effects after the removal of the Toothtutor were seen in Experiment 6 than during any previous procedure. This suggests that a weekly hygiene test, with the score posted on a calendar, may function as reinforcer for 'good' brushing behaviour. Nevertheless, although most of the children in Experiments 3, 4 and 5 tended to spend more time brushing their teeth during the two-month Follow-ups (both with and without the Toothtutor) than they had done in Baseline, and despite the improved long term maintenance in Experiment 6, no subject has yet spent as much time brushing during the Follow-ups as they have done during training.

Nevertheless, it has now been shown that children can learn to spend regularly a full two minutes brushing their teeth twice each day without (i) explicit prompts from their parents to begin brushing, or (ii) assistance from their parents during the brushing event. It has been shown that improving children's toothbrushing behaviour appears to lead to improvements in their dental hygiene, but it remains to be investigated whether there is a more 'cost efficient' way of achieving the same effects, and whether there is a more effective way of maintaining the improved toothbrushing behaviour. These two issues are addressed in Chapter 5.

The effects observed in the current experiments could not have come about without verbal instructions and therefore must be interpreted in terms of rule governed behaviour. According to Hayes, Zettle and Rosenfarb (1989), all rule governed behaviour makes contact with two types of contingencies: the natural contingencies and those established by the rule and past history with rules. Rules can specify either contrived (socially mediated) or natural contingencies. Initially, in all of the current experiments, the children's rule following must be seen as pliance since presumably the children follow a rule such as *"Every night and every morning I will brush every part of my teeth and gums"* primarily in order to gain the socially mediated material rewards. In Experiments 5 and 6, an attempt was made to promote tracking (as well as pliance during Compliance Training) by making the natural consequences of toothbrushing more immediately and frequently apparent. This may have been partially effective in Experiment 6, but since during the Follow-ups behaviour was not maintained at the level reached during Compliance Training, the highlighted natural consequences of toothbrushing did not control rule following (tracking) as effectively as the socially mediated contingencies that promoted pliance (and possibly tracking) during training.

Evidence from Experiments 3 and 4 (see Section 3.2 Discussion) suggests the possibility that reducing the amount of exposure to a continuous reinforcement condition may improve short term and long term maintenance. It was suggested that the rewards (books, toys and games) may begin to lose their reinforcing function if delivered frequently over a prolonged period. If this is the case, it is possible that reducing the total number of rewards that can be earned, and increasing the time delay between the delivery of successive rewards may enhance intervention and maintenance effects. A reduced continuous reinforcement condition (Compliance Training) followed by a longer Maintenance condition, in which the contrived (socially mediated) contingencies are withdrawn even more gradually than has been the practice in the experiments described thus far, may produce even greater long term changes in behaviour.

CHAPTER 5.

COMPONENT ANALYSIS: QUANTITY AND INTENSITY OF TRAINING, AND THE ROLE OF MATERIAL REWARDS.

5.1 EXPERIMENT 7

This experiment was designed to examine the effects of (i) condensing still further the refined training package implemented in the previous experiment, and (ii) increasing the duration of the Maintenance condition. After Baseline in Experiment 6 the hygiene test procedure was introduced several days before the Compliance Training contingency and the Toothtutor. In Experiment 7 the number of intervention conditions was reduced by introducing the Compliance Training contingency and the Toothtutor on the same day as the hygiene test procedure. The minimum length of the intensive training condition (before the introduction of Maintenance) was set at nine days in Experiment 6. In Experiment 7 this minimum was set at four days in order to test the effectiveness of a shorter intensive training period. In contrast, the length of the Maintenance condition was *increased* to forty days to determine whether extra exposure to this intermittent reinforcement condition would improve long-term maintenance of the treatment effects. An attempt was also made in this experiment to involve the parents more fully in the decision making processes necessary for successful implementation of the procedures.

METHOD

PARTICIPANTS

(a) **Subjects**

Two girls (Tina and Louise) and a boy (Stuart) took part. Their mean age was 5 years 7 months (see Table 5.1.1 for complete subject and sibling details).

TABLE 5.1.1

AGE OF SUBJECTS AND THEIR SIBLINGS

EXPERIMENT 7

Subject	Age at start	Number of Siblings	Age of Siblings
Tina	5 yrs 3 mths	1	3 yrs
Stuart	5 yrs 6 mths	0	-
Louise	5 yrs 10 mths	0	-

Mean age of subjects = 5 yrs 7 mths

(b) **Parents**

Most of the time the procedures were implemented by Tina's father, but occasionally when he could not be present, Tina's mother obliged. Stuart (from a single parent family) and Louise were instructed only by their mothers.

DEPENDENT VARIABLES AND RECORDING

(a) **Target Behaviours**

The dependent variables were the same as in Experiments 5 & 6, and data were collected in exactly the same way.

(b) **Reliability**

The overall agreement between the two observers calculated by the Frequency Ratio method was 96.1% for duration and 92.3% for locations. For Tina agreement was 99.8% for duration and 92.3% for locations; for Stuart it was 93.6% and 89.6% respectively; for Louise it was 94.8% and 94.9%. The correlations between the observers scores for duration and for locations were: overall 0.975 and 0.902; for Tina, 0.982 and 0.917; for Stuart, 0.975 and 0.926; for Louise, 0.969 and 0.864.

EXPERIMENTAL DESIGN

Baselines in this experiment were six days (Tina), nine days (Stuart), and twelve days (Louise). After baseline all of the subjects were exposed to the following intervention conditions:

(1) Hygiene Tests + Compliance Training + Toothtutor

(2) Maintenance of Compliance.

PROCEDURE

Hygiene Tests + Compliance Training + Toothtutor

This condition was similar to that in Experiment 6, except that (i) it was not preceded by a condition of daily hygiene tests without verbal instructions or a contingency concerning tooth-brushing, and (ii) it was designed to be much shorter, lasting for only four days if the subject gained a material reward on each of those days. If the subject was not 100% successful on the first four days, the condition was continued until the subject gained a reward on three consecutive occasions. No information was given to parents from the video recordings of their children's behaviour, and it was left to the parents to decide, on the basis of their child's frequency of toothbrushing and hygiene scores, when the next condition should be introduced.

Maintenance of Compliance

The instructions and opportunities for gaining material reward were systematically faded exactly as in Experiment 6. Initially the hygiene test was conducted after two days, then after three days, and then once a week (on a different randomly allocated day each week) for the rest of this condition. The principles of the procedure were explained to the parents, who were then encouraged to implement it with as little guidance from the experimenter as was necessary.

Follow-up

The procedures after the Maintenance condition were the same as in Experiment 6, except that period before the first Follow-up condition was now nine weeks.

RESULTS

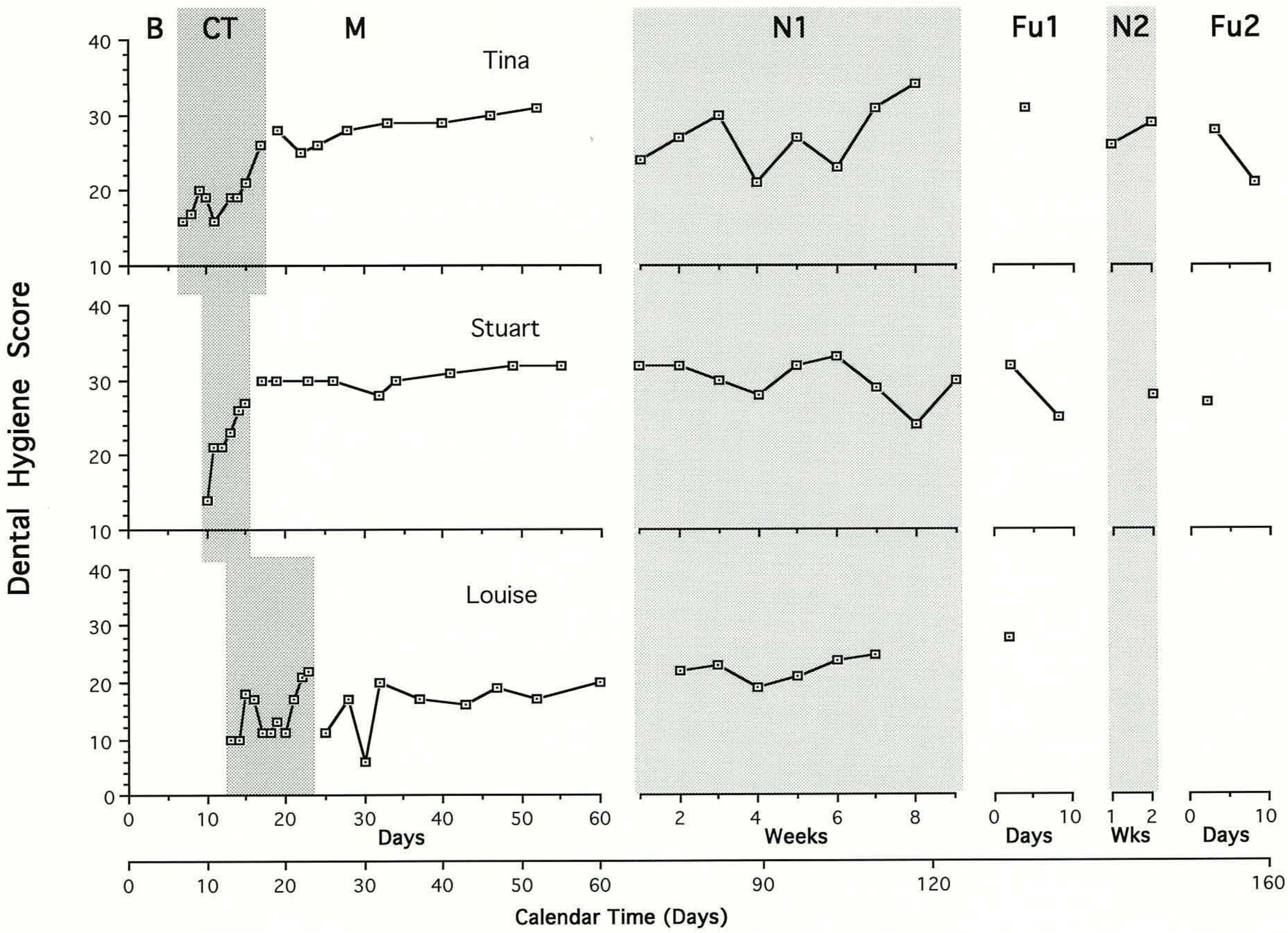
Dental Hygiene

Figure 5.1.1 shows that the dental hygiene scores of all three subjects increased during the Compliance Training condition (CT). Because Stuart's hygiene scores improved rapidly and consistently, he was exposed to this condition for only six days before the contingencies were altered and the Maintenance condition (M) was introduced. Tina was exposed to the Compliance Training condition for ten days, and Louise for eleven days, before meeting the criterion for a change in contingencies.

Tina's hygiene scores were stable and high throughout the Maintenance condition (range, 25 - 31) compared to her scores during the first 8 days in the Compliance Training condition (range, 16 - 20). Her scores fluctuated more in the conditions following Maintenance (N1, Fu1, N2 and Fu2), but on each occasion they remained higher than on any of the first 8 days of Compliance Training (range, 21 - 34). Stuart's highest score on the first three days of the Compliance Training condition was 21. His scores were consistently higher than this on all of the twenty five occasions that they were checked during the next twenty one weeks (range, 23 - 33). Louise's hygiene scores were initially rather erratic, but on every occasion after the third hygiene test in the Maintenance condition (Day 30) they remained high and stable. There is no data for Louise after the first Follow-up (Fu1) because her family unexpectedly emigrated.

Figure 5.1.1

The Hygiene Test scores supplied by each subject's parents during each of the four experimental phases of the study, Hygiene Tests + Compliance Training + Toothtutor (CT), Maintenance (M) and Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it), the 9 week period between Maintenance and the first Follow-up (N1), and the 2 week period between the first and second Follow-ups (N2).



B
CT
M
N1
Fu1
N2
Fu2
Tina
Stuart
Louise
Dental Hygiene Score
Days
Weeks
Days
Wks
Days
Calendar Time (Days)

Figure 5.1.1

Frequency of Toothbrushing

Figure 5.1.2 and Table 5.1.2 show that all three subjects brushed their teeth more frequently after the introduction of the hygiene tests, Compliance Training contingencies, and the Toothtutor than they did in Baseline (B). The subjects maintained their improved frequencies throughout the Compliance Training condition (CT) and Maintenance (M).

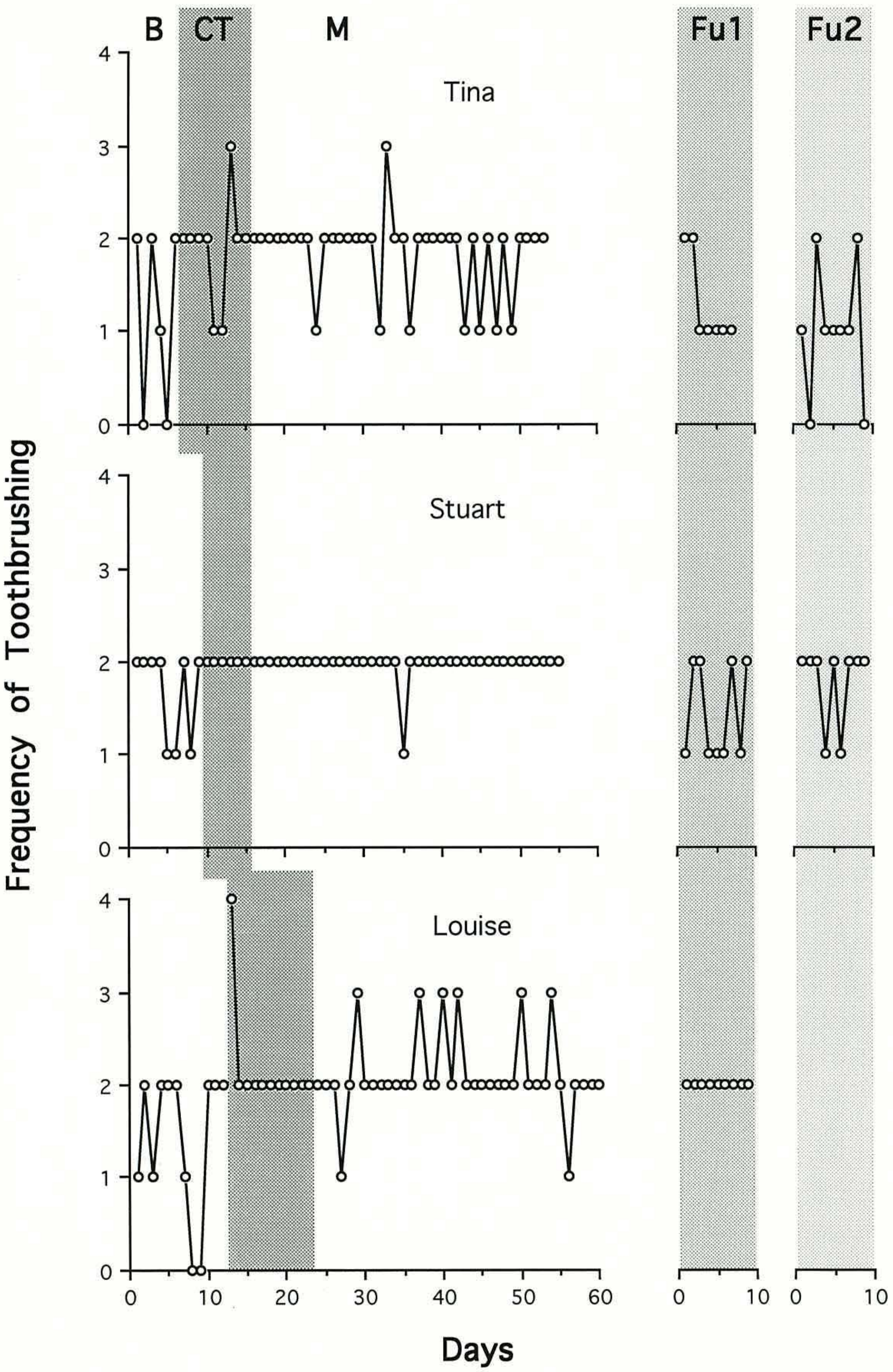
Tina brushed three times a day twice (Day 13 and Day 33), and on both occasions this was because she brushed twice at night, once before a hygiene test, and once after it. Louise brushed four times on the first day of Compliance training (three times in the evening), and three times a day on six occasions during Maintenance, sometimes brushing twice at night, and sometimes twice in the morning, and on only one occasion did she brush *after* a hygiene test at night.

Tina and Stuart brushed less frequently during the Follow-ups (Fu1 and Fu2) than they had done in Maintenance, and their means for these conditions were close to the Baseline level. Louise, however, whose mean in Baseline was 1.42 times per day, and who was only exposed to the first Follow-up, brushed twice a day every day during this final condition. Tina's first Follow-up was only seven days long because she contracted chicken pox and was ill on the seventh day. She had completely recovered before the beginning of the second Follow-up condition.

Figure 5.1.2

Frequency of toothbrushing per day for each subject during each experimental phase: Baseline (B), Hygiene Tests + Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Figure 5.1.2



B
CT
M
Fu1
Fu2
Tina
Stuart
Louise
Frequency of Toothbrushing
Days
0
10
20
30
40
50
60
0
10
0
10
0
1
2
3
4

TABLE 5.1.2

Mean Frequency of Toothbrushing

Experiment 7

Each subject's frequency of toothbrushing per day, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Hygiene Tests + Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions				
	B	**CT**	**M**	**Fu1**	**Fu2**
Tina					
Mean	1.17	1.89	1.84	1.29	1.00
Std D	0.98	0.60	0.44	0.49	0.71
N	6	9	38	7	9
Range	0 - 2	1 - 3	1 - 3	1 - 2	0 - 2
Stuart					
Mean	1.67	2.00	1.98	1.44	1.78
Std D	0.50	0	0.16	0.53	0.44
N	9	6	40	9	9
Range	1 - 2	2 - 2	1 - 2	1 - 2	1 - 2
Louise					
Mean	1.42	2.20	2.11	2.00	*
Std D	0.79	0.63	0.45	0	*
N	12	10	38	9	*
Range	0 - 2	2 - 4	1 - 3	2 - 2	*
Overall Mean	1.42	2.03	1.98	1.58	1.39

* Subject withdrawn from the study

Mean Duration of Toothbrushing per Occasion

It can be seen from Figure 5.1.3 and Table 5.1.3 that the mean duration of toothbrushing per occasion of all three children was considerably higher on almost every day during the Hygiene Tests + Compliance Training + Toothtutor condition (CT) and Maintenance (M) than at any time during Baseline (B).

Tina's durations were extremely high on the first three days of Compliance Training (Days 7 - 9), and less high on the next three days (Days 10 - 12). Her hygiene scores reflected this change (see Figure 5.1.1), and because she was not rewarded when her hygiene scores declined, she was exposed to the relationship between the duration of toothbrushing and the dental hygiene contingency. Tina increased her mean duration of toothbrushing per occasion again for the next three days (Days 13 - 15), was rewarded on each of these days because her hygiene scores also improved, and so the Maintenance condition was introduced the following day (Day 16).

A similar though less dramatic pattern can be seen in Louise's data. Her slight drop in durations after the third day of exposure to Compliance Training (Day 15) was mirrored by a drop in hygiene scores, which meant that she was not rewarded. An increase in her mean duration per occasion a few days later (Day 21) resulted in an improved hygiene score, and therefore a reward.

Figure 5.1.3

Mean duration of toothbrushing per occasion per day for each subject during Baseline (B), Hygiene Tests + Compliance Training + Toothtutor (CT), Maintenance (M) and both two month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). These data were calculated by totalling all the recorded durations each day, and dividing this sum by the daily frequency.

Figure 5.1.3

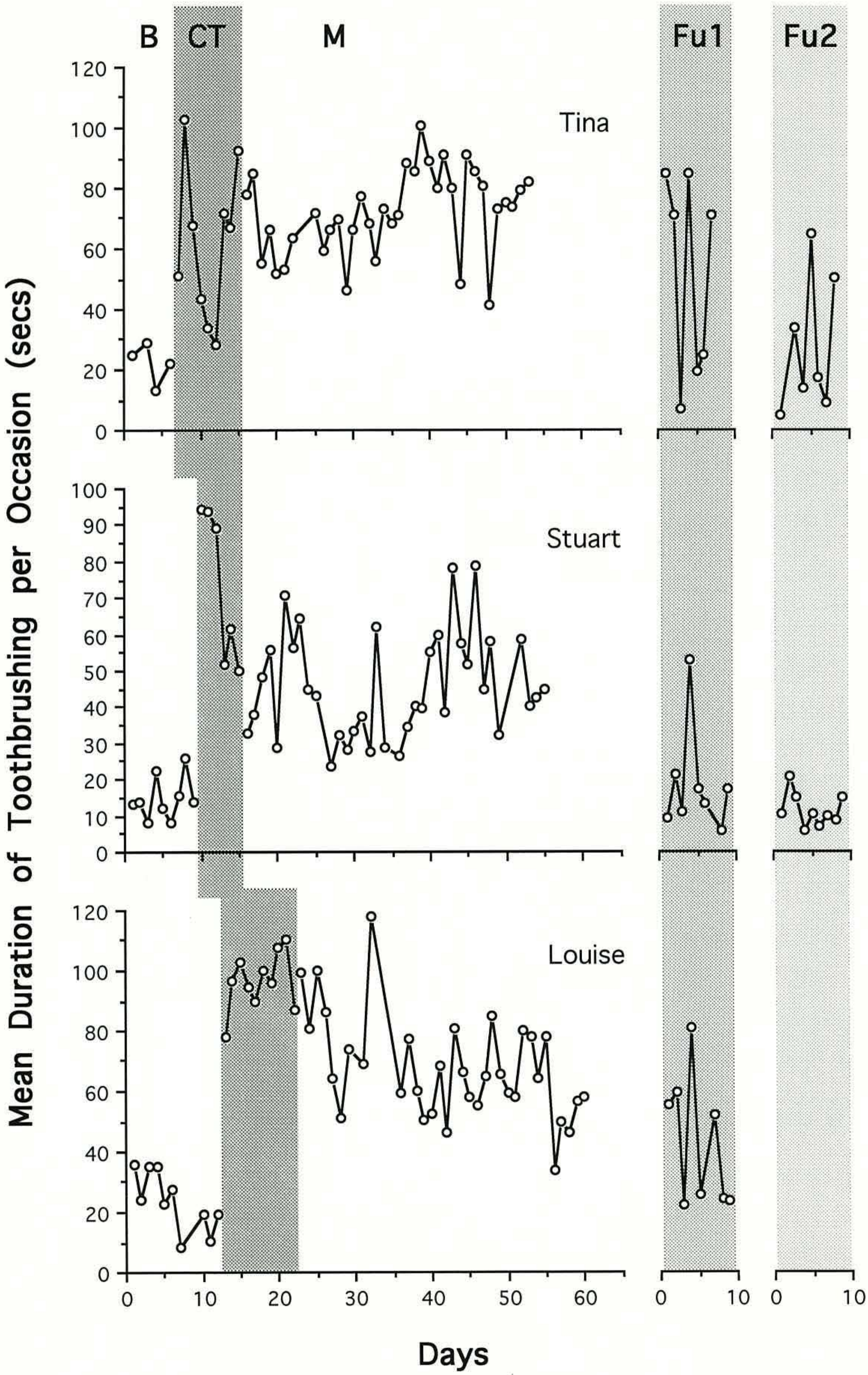

B
CT
M
Fu1
Fu2
Tina
Stuart
Louise
Mean Duration of Toothbrushing per Occasion (secs)
Days
0
10
20
30
40
50
60
100
120
70
80
90

TABLE 5.1.3

Mean Duration of Toothbrushing per Occasion

Experiment 7

Each subject's mean duration of toothbrushing per occasion per day, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Hygiene Tests + Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions				
	B	**CT**	**M**	**Fu1**	**Fu2**
Tina					
Mean	22.25	61.94	71.94	51.86	27.79
Std D	6.80	25.30	14.08	33.52	22.80
N	4	9	36	7	7
Min	13.00	28.00	41.50	7.00	5.00
Max	29.00	102.50	101.00	85.00	65.00
Stuart					
Mean	14.83	73.25	45.50	18.38	11.44
Std D	6.01	21.17	14.70	14.80	4.60
N	9	6	36	8	9
Min	8.00	50.00	23.50	6.00	6.00
Max	26.00	94.00	79.00	53.00	20.50
Louise					
Mean	23.65	96.23	67.45	42.75	*
Std D	9.93	9.69	17.44	22.11	*
N	10	10	34	8	*
Min	8.00	77.75	34.00	22.00	*
Max	36.00	110.00	118.00	81.00	*
Overall Mean	20.24	77.14	61.63	37.73	19.65

* Subject withdrawn from the study

The relationship between the mean durations of toothbrushing per occasion and the hygiene scores was less clear in Stuart's case. His durations fell sharply after the third day of Compliance Training (Day 12), but his hygiene scores continued to increase steadily. Nevertheless, despite the drop, Stuart's minimum duration of toothbrushing per occasion was 50 seconds in this condition, compared with his maximum of 26 seconds in Baseline, and his overall mean duration per occasion was almost five times his Baseline mean (see Table 5.1.3).

Mean durations of toothbrushing per occasion remained fairly high in all cases throughout the extended Maintenance condition (M), and Tina's average in this condition was higher than it was during initial training (CT). However, two months later in the first Follow-up (Fu1), the subjects brushed quite erratically. The mean durations of toothbrushing per occasion of both Tina and Louise were high (well above Baseline levels) on four random days in this condition and low on the others. Their overall mean durations for this phase were much lower than in Maintenance, but were still double their means for Baseline (see Table 5.1.3). As mentioned previously, due to unforseen circumstances Louise was withdrawn from the study after the end of Follow-up 1, so no data could be collected for her in Follow-up 2. Tina's durations continued to be variable in this second Follow-up (when the Tutor had been removed), but were generally lower than in the first Follow-up. The third subject (Stuart) brushed at Baseline levels on all but one day (Follow-up 1, Day 4) in both of the Follow-up conditions.

Total Duration of Toothbrushing per Day

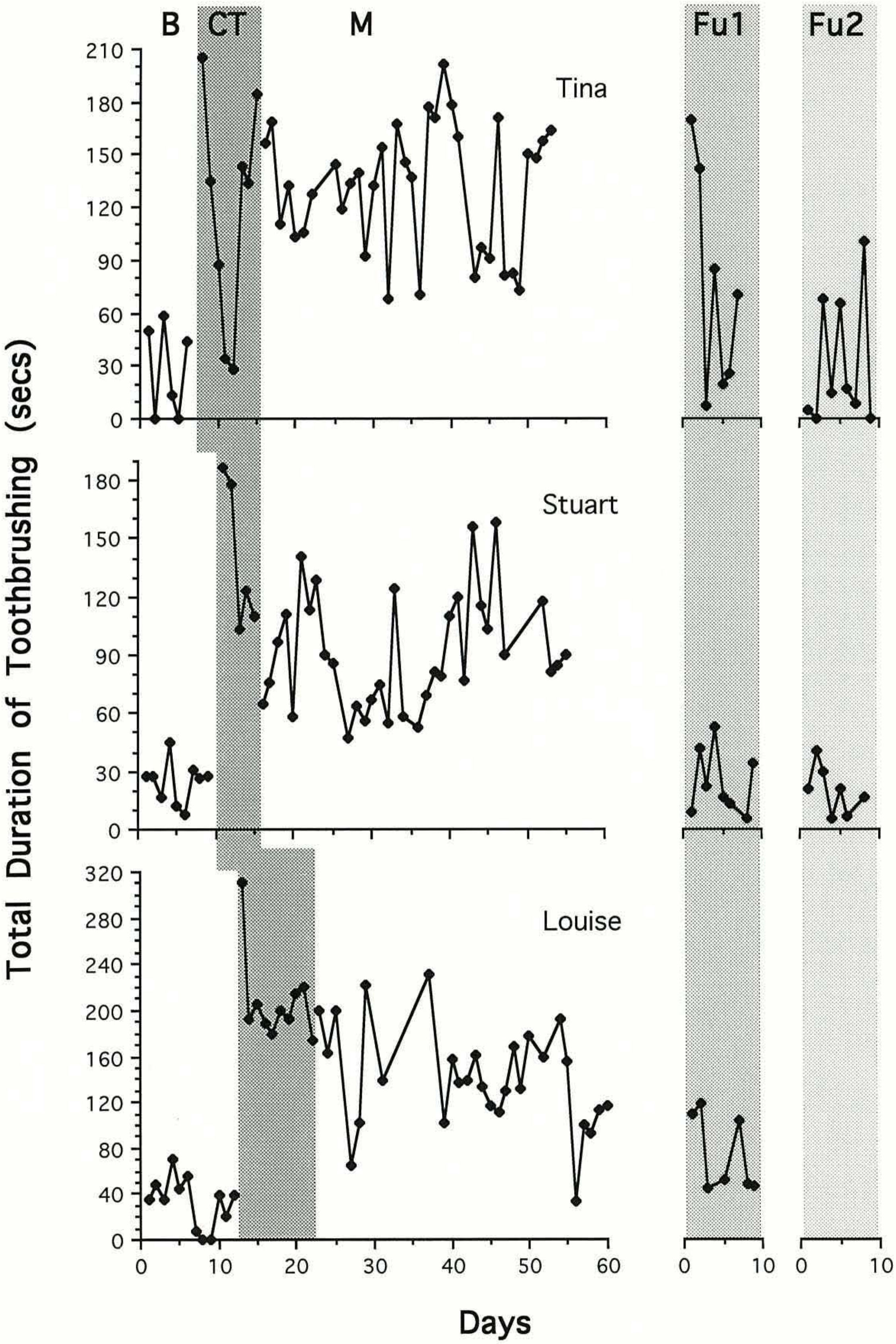
Figure 5.1.4 shows the total durations of toothbrushing per day for each of the subjects, and Figure 5.1.5 shows each subject's mean frequency and mean total duration of toothbrushing per day in each of the conditions in Experiment 7. The data presented in Table 5.1.4 are the difference scores between the Baseline mean total duration per day and the mean total duration per day in each of the subsequent phases, expressed as a percentage of the Baseline duration.

Clear improvements can be seen immediately after the introduction of the Hygiene Tests + Compliance Training + Toothtutor condition (CT). All three subjects brushed for longer on the first day of this phase than on any other day. Louise maintained total durations of close to 200 seconds on most days in this Compliance Training condition, and Stuart never spent less than 100 seconds. Tina's total duration per day fell to Baseline level on two days in the middle of the phase (Days 11 and 12), but then rose again sharply (to over 130 secs per day) on the last three days of exposure to this condition (Days 13 - 15). On average all three subjects spent more than 330% more time brushing their teeth in the Hygiene Tests + Compliance Training + Toothtutor condition than they had done in Baseline.

Figure 5.1.4

Total duration of toothbrushing per day for each of the subjects during Baseline (B), Hygiene Tests + Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). Data for this figure were calculated by totalling known durations of all toothbrushing events that occurred on each day.

Figure 5.1.4

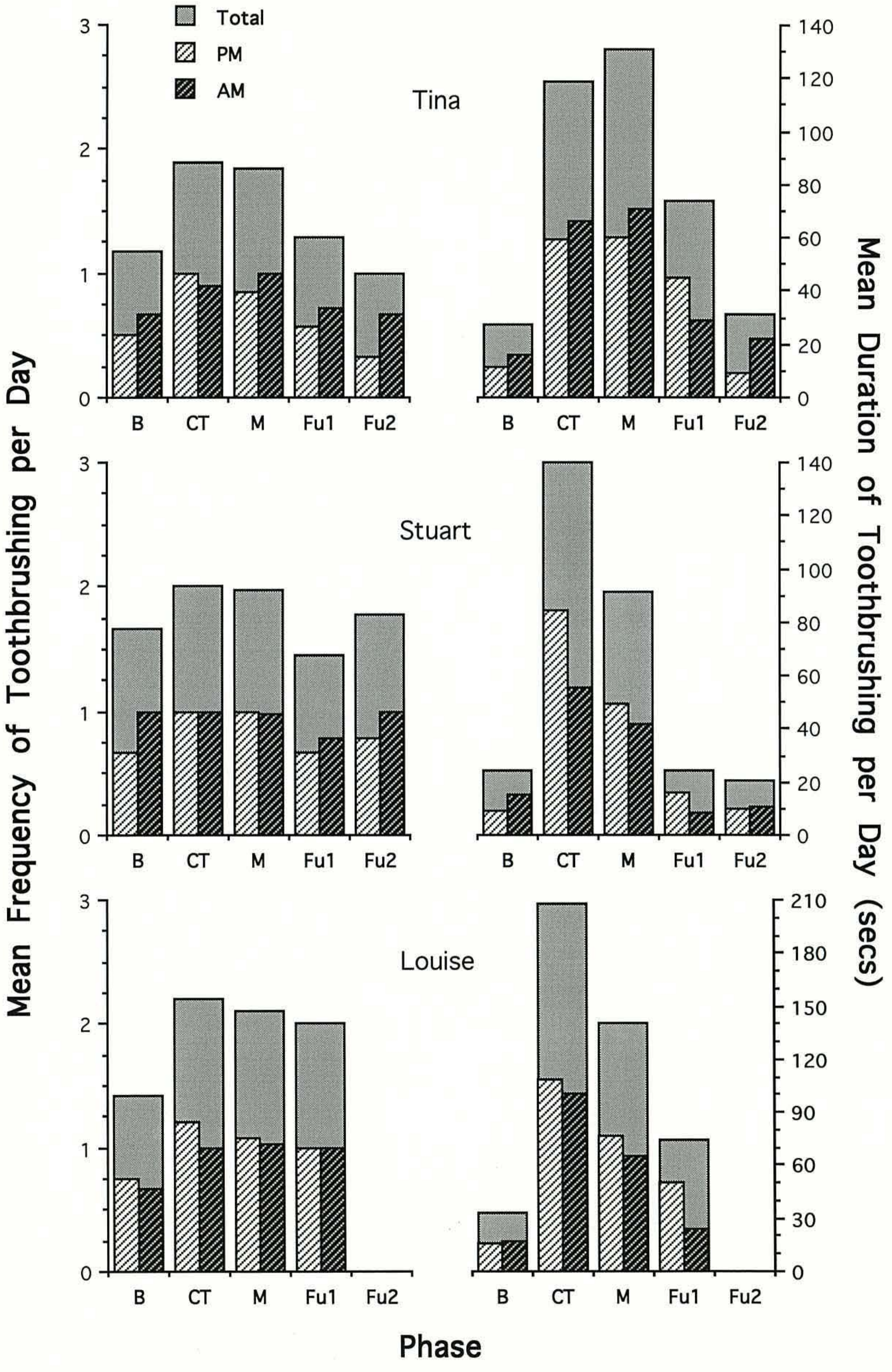


B
CT
M
Fu1
Fu2
Tina
Stuart
Louise
Total Duration of Toothbrushing (secs)
Days

Figure 5.1.5

The mean frequency of toothbrushing per day (left side) and the mean total duration of brushing per day (right side) for each subject in each of the phases. The means for evening (light diagonal line shading) and morning sessions (dark diagonal line shading) in each phase are also shown. Data for the frequency graph (left side) were calculated by totalling the number of brushing events that occurred at night and in the morning, and dividing by the total number of days in the phase. Data for the duration graph were calculated by totalling each subject's known durations at night and in the morning in each phase and dividing by the total number of sessions (of known duration) in the phase.

Figure 5.1.5



Total
PM
AM
Tina
Stuart
Louise
Mean Frequency of Toothbrushing per Day
Mean Duration of Toothbrushing per Day (secs)
B
CT
M
Fu1
Fu2
Phase

TABLE 5.1.4

Mean Total Duration Difference Scores

Experiment 7

The percentage difference between each subject's Baseline mean total duration per day and his/her mean total duration per day in all subsequent phases: Baseline (B), Hygiene Tests + Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Sessions	Experimental Conditions			
	CT	**M**	**Fu1**	**Fu2**
Tina				
PM	409%	416%	286%	- 23%
AM	316%	348%	84%	39%
Total	**332%**	**377%**	**170%**	**13%**
Stuart				
PM	817%	436%	74%	7%
AM	263%	172%	- 45%	- 31%
Total	**471%**	**271%**	**0%**	**- 17%**
Louise				
PM	590%	385%	223%	*
AM	482%	277%	40%	*
Total	**534%**	**329%**	**127%**	*
Overall Mean	**446%**	**326%**	**99%**	**- 2%**

* Subject withdrawn from the study

The total durations per day of all three subjects remained high on most days (a mean of more than 270% higher than Baseline) during exposure to the extended Maintenance condition (M). Two months later, however, Stuart's frequency and total durations of toothbrushing per day were much the same as in Baseline, both in the presence of the Toothtutor (Fu1), and in its absence (Fu2). The performance of Tina and Louise was erratic during the first Follow-up, but their mean total durations in this condition were still higher than in Baseline (170% and 127% respectively). The difference between Tina's performance in the the second Follow-up (when the Toothtutor had been removed) and her performance in Baseline was negligible. Her frequency of toothbrushing dropped below the Baseline level, and her total durations per day were 13% higher than Baseline.

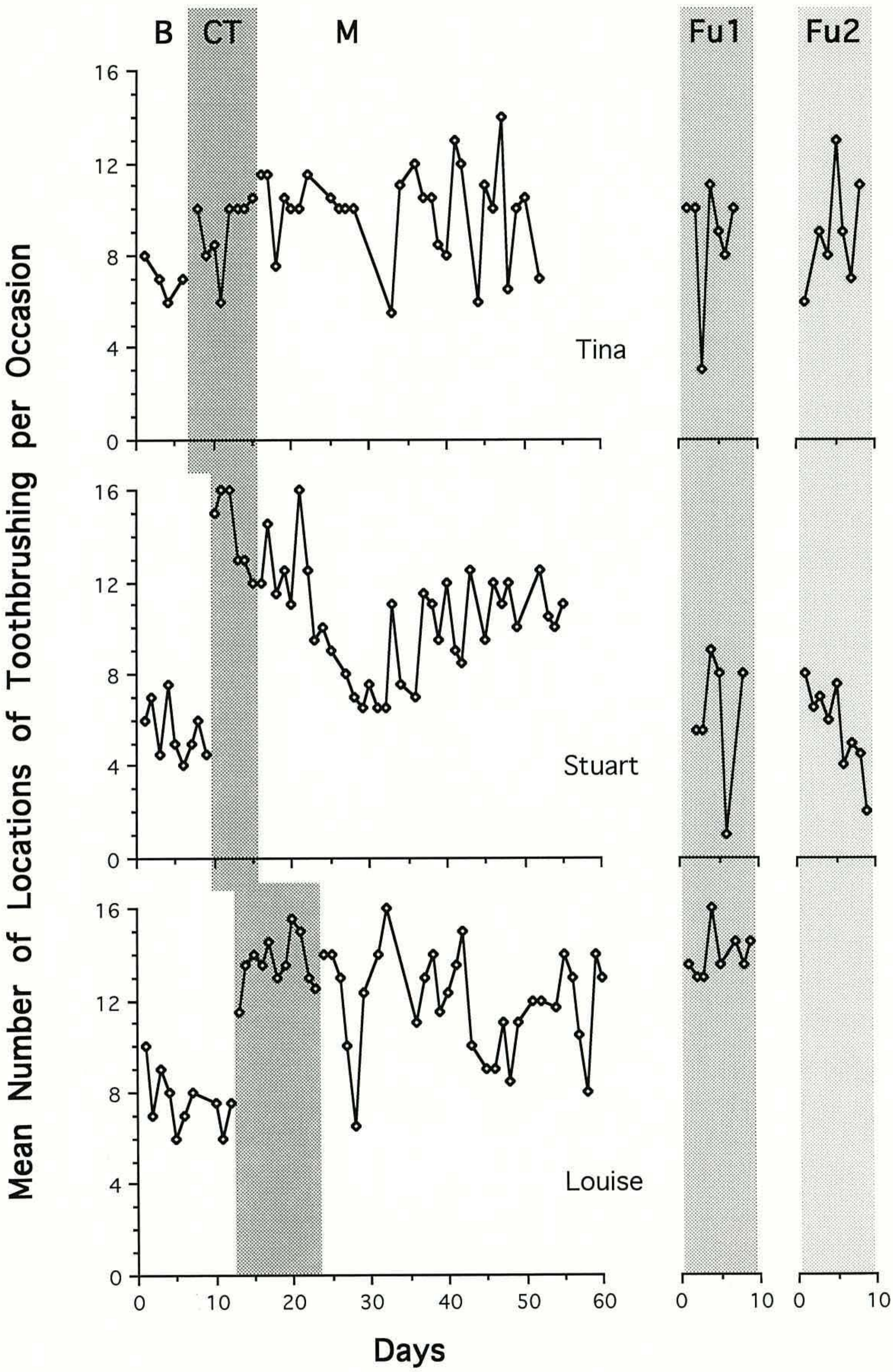
Locations of Toothbrushing

Figure 5.1.6 and Table 5.1.5 show that as was the case with mean durations per occasion, all three subjects' mean number of locations brushed per occasion was increased after the introduction of the hygiene tests, the Toothtutor, and the Compliance instructions and contingencies. The change is most clear in the data for Stuart and Louise, who both brushed more than 11 locations per toothbrushing occasion on every day that they were exposed to the Compliance Training condition (CT). Tina never learned to brush as many locations during each brushing session as the other two subjects, but nevertheless, her mean in each condition following the intodution of the Toothtutor was higher than in Baseline (see Table 5.1.5).

Figure 5.1.6

Mean number of locations brushed per occasion per day for each subject during Baseline (B), Hygiene Tests + Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). These data were calculated by adding together the number of locations brushed on each occasion each day, and dividing this sum by the frequency.

Figure 5.1.6



B
CT
M
Fu1
Fu2
Mean Number of Locations of Toothbrushing per Occasion
Tina
Stuart
Louise
16
12
8
4
0
0
10
20
30
40
50
60
0
10
0
10
Days

TABLE 5.1.5

Mean Number of Locations of Toothbrushing per Occasion

Experiment 7

Each subject's mean number of locations of toothbrushing per occasion per day, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Hygiene Tests + Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions				
	B	**CT**	**M**	**Fu1**	**Fu2**
Tina					
Mean	7.00	9.13	9.96	8.71	9.00
Std D	0.82	1.53	2.05	2.69	2.38
N	4	8	28	7	7
Min	6.00	6.00	5.50	3.00	6.00
Max	8.00	10.50	14.00	11.00	13.00
Stuart					
Mean	5.50	14.17	10.24	6.17	5.61
Std D	1.20	1.72	2.31	2.91	1.92
N	9	6	35	6	9
Min	4.00	12.00	6.50	1.00	2.00
Max	7.50	16.00	16.00	9.00	8.00
Louise					
Mean	7.60	13.70	11.91	13.94	*
Std D	1.24	1.15	2.20	1.02	*
N	10	10	31	8	*
Min	6.00	11.45	6.50	13.00	*
Max	10.00	15.50	16.00	16.00	*
Overall Mean	6.70	12.33	10.70	9.61	7.31

* Subject withdrawn from the study

Stuart's mean number of locations brushed per occasion in the Maintenance condition (M) was almost twice the Baseline level, but as with his mean durations per occasion, his perfomance in the Follow-ups (even when the Toothtutor was present) was similar to that in Baseline. In contrast, Louise never brushed fewer than 13 locations per occasion in the first two-month Follow-up, and her mean for this condition was almost twice her mean for Baseline.

Inter-Experimental Comparison

Figure 5.1.7 gives a rough impression of the intervention and maintenance effects in Experiments 6 and 7. It is a comparison of the mean total duration of toothbrushing across all subjects in four conditions of each experiment: Baseline (before the introduction of the hygiene tests), Compliance Training + Toothtutor, Maintenance, and Follow-up 1. Presented in Table 5.1.6 is the mean frequency and the mean duration per occasion for all of the subjects in the same four conditions of Experiments 6 and 7. Data from the second Follow-up are not included because, as one of the three subjects who participated in Experiment 7 (Louise) withdrew at the end of the first Follow-up, the mean data from Follow-up 2 are not compatible with those from the rest of the study.

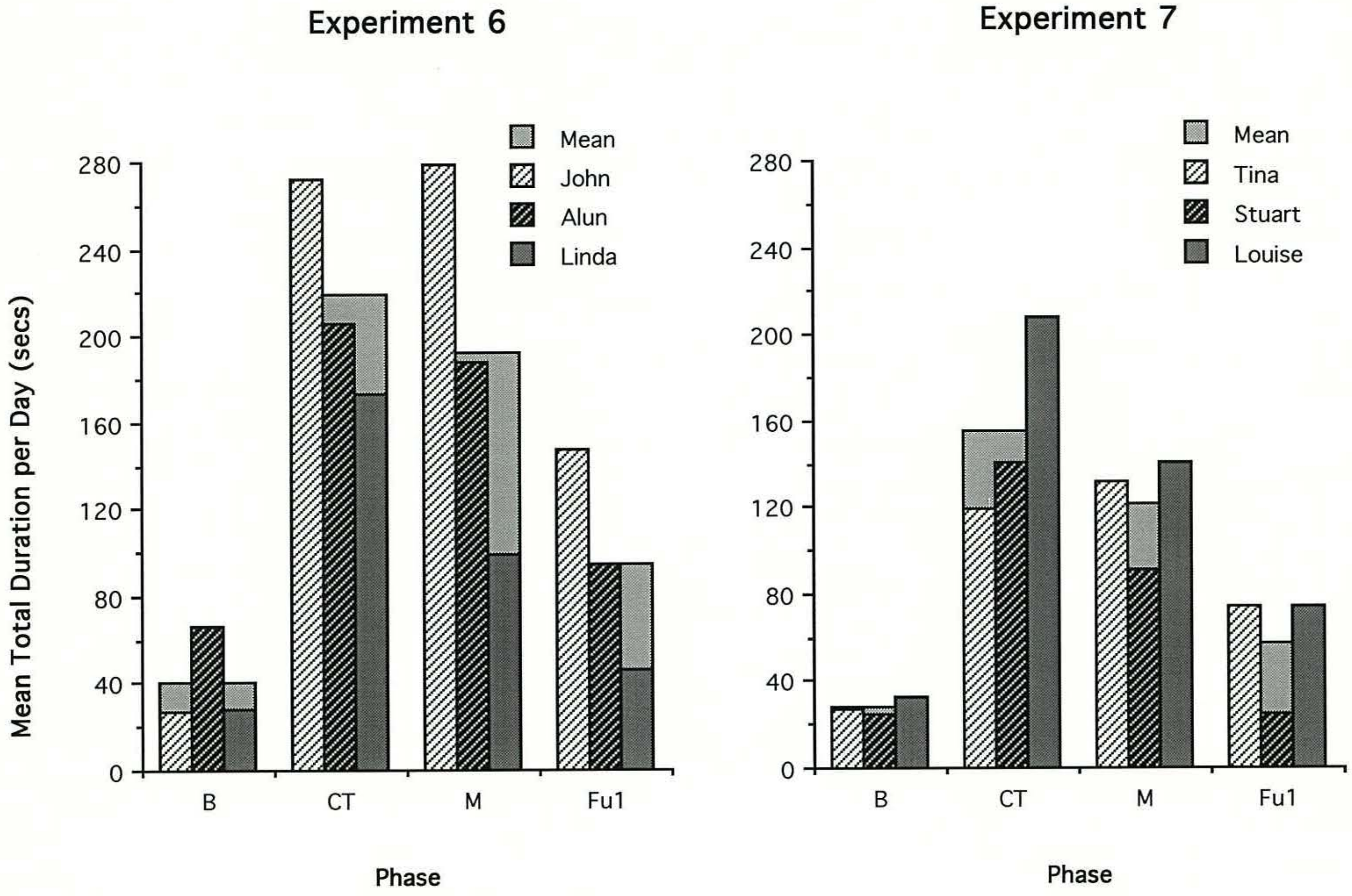
Two subjects in Experiment 6 (Alun and Linda) tended to brush more frequently during Baseline (B) than any of the subjects in Experiment 7, and two of them (John and Alun) tended to brush for longer per occasion than any of the subjects in Experiment 7. The resulting mean total durations per day across all subjects in Baseline were 40.60 seconds for Experiment 6 and 28.30 seconds for Experiment 7. The mean frequencies in the two experiments were very similar during the Compliance Training conditions (CT), but the mean durations per occasion of two subjects in Experiment 6 (John and Alun) were higher than those of any of the subjects in Experiment 7, and the mean total duration per day was 219.75 seconds for Experiment 6 compared to 155.69 seconds for Experiment 7.

All of the subjects sustained a high frequency of toothbrushing in the Maintenance conditions (M), but the mean duration per occasion of two subjects in Experiment 7 (Stuart and Louise) were much less than they had been in the previous condition. This led to bigger drop in the overall mean total duration per day in Experiment 7 than in Experiment 6. In Follow-up 1 (Fu1) all of the subjects brushed less frequently and for less time than they had done in Maintenance, but their mean total durations were still much higher than in Baseline.

Table 5.1.7 shows the difference scores between the Baseline mean total durations, and the mean total durations in 3 subsequent conditions of Experiments 6 and 7. It can be seen from this table that despite the individual and group differences in absolute values discussed above, the group mean difference scores were very similar in each of the corresponding conditions in the two experiments.

Figure 5.1.7

Mean total duration of toothbrushing per day for all subjects in each of four phases, Baseline (B), Compliance Training + Toothtutor (CT), Maintenance (M) and the first two month Follow-up (Fu1 - with the Toothtutor) in Experiments 6 (left side), and Experiment 7 (right side). The mean data were calculated by totalling each subject's mean total duration per day in each phase and dividing by the total number of subjects in each experiment.



Experiment 6
Mean
John
Alun
Linda
Mean Total Duration per Day (secs)
280
240
200
160
120
80
40
0
B
CT
M
Fu1
Phase
Experiment 7
Mean
Tina
Stuart
Louise
280
240
200
160
120
80
40
0
B
CT
M
Fu1
Phase

Figure 5.1.7

TABLE 5.1.6

Mean Frequency and Duration per Occasion

Experiments 6 and 7.

The mean frequency and mean duration of toothbrushing per occasion per day in 5 conditions of Experiment 6, and Experiment 7: Baseline (B), Compliance Training + Toothtutor (CT), Maintenance (M) and the first two-month Follow-up (Fu1 - with the Toothtutor. The values of each of the subjects' means are also shown.

Experimental Details Measures, and Subjects	Experimental Conditions			
	B	**CT**	**M**	**Fu1**
EXPT. 6+ (N = 3 Ss)				
FREQUENCY - MEAN	**1.57**	**2.12**	**1.90**	**1.74**
John	1.00	2.00	2.25	2.00
Alun	1.89	1.91	1.89	1.78
Linda	1.83	2.44	1.56	1.44
DURATION - MEAN	**26.14**	**107.39**	**100.87**	**50.81**
John	27.50	136.94	131.56	56.21
Alun	35.72	109.55	100.79	51.83
Linda	15.21	75.67	70.26	44.38
EXPT. 7+ (N = 3 Ss)				
FREQUENCY - MEAN	**1.42**	**2.03**	**1.98**	**1.58**
Tina	1.17	1.89	1.84	1.29
Stuart	1.67	2.00	1.98	1.44
Louise	1.42	2.20	2.11	2.00
DURATION - MEAN	**20.24**	**77.14**	**61.63**	**37.73**
Tina	22.25	61.94	71.94	51.86
Stuart	14.83	73.25	45.50	18.38
Louise	23.65	96.23	67.45	42.75

+ Hygiene tests during conditions CT, M, and Fu1.

TABLE 5.1.7

Mean Total Duration Difference Scores

Experiments 6 and 7

The percentage difference between mean Baseline total durations per day and mean total durations per day in 3 subsequent conditions in Experiment 6 and Experiment 7: Compliance Training + Toothtutor (CT), Maintenance (M) and the first two-month Follow-up (Fu1 - with the Toothtutor).

Experiments and Subjects	Experimental Conditions		
	CT	**M**	**Fu1**
Experiment 6			
Mean	**441%**	**375%**	**132%**
John	888%	913%	435%
Alun	209%	182%	42%
Linda	523%	258%	66%
Experiment 7			
Mean	**446%**	**326%**	**99%**
Tina	332%	377%	170%
Stuart	471%	271%	0%
Louise	534%	329%	127%

DISCUSSION

This experiment has shown that a condensed version of the refined training package implemented in the previous experiment can be used to improve the toothbrushing behaviour and dental hygiene of young children. Frequency, duration and number of locations of toothbrushing were greatly improved after the introduction of the Compliance Training contingency and the Toothtutor on the same day as the hygiene tests. Whether this procedure was as effective as that in Experiment 6 remains uncertain. During training subjects in Experiment 7 did not brush for as long as the subjects in Experiment 6, and they also spent less time brushing in the Maintenance and Follow-up conditions. However, their mean total duration per day was also lower in Baseline, and as a result the mean difference scores for the different conditions of Experiment 7 were much the same as those for Experiment 6 (see Table 5.1.7).

The attempt to reduce the number of days of exposure to the Compliance Training condition was not entirely successful. Because subjects' performance was required to meet the pre-set criterion of 3 consecutive days of brushing twice a day and improving hygiene scores before the Maintenance condition could be introduced, only one of the subjects (Stuart) was exposed to less than nine days of the Compliance Training condition. The other two subjects did not meet the criterion for the introduction of the Maintenance condition until 9 and 10 days of intensive training. Stuart's behaviour during the Compliance Training and Maintenance conditions was comparable to that of the other subjects, but his performance in the two-month Follow-ups was not as good. This suggests that contrary to what was expected, exposure to the intensive Compliance Training condition for less than nine days may actually retard long term maintenance. This, however, can only be an extremely tentative proposal on the basis of data from only one subject. Conclusions about the effects on long term maintenance of the number of days of exposure to a continuous reinforcement condition could only be drawn after further experiments in which this variable is systematically varied.

Also, it certainly cannot be concluded from the current experiment that increasing the number of days of exposure to an *intermittent* reinforcement condition leads to better long term maintenance effects. The length of the Maintenance condition was increased to forty days in Experiment 7, but the Follow-up performance of the subjects in this study was no better than that of subjects in previous experiments.

The attempt to involve parents more fully in the decision making processes about implementation of the procedures was very successful. Communication from the experimenter to the parents was confined primarily to basic written instructions, and these needed very little extra vis-a-vis clarification.

5.2 EXPERIMENT 8

Experiment 7 has shown that a simplified procedure that includes just two intervention conditions can improve children's toothbrushing behaviour and their dental hygiene. The procedure was more 'cost efficient' than those used in previous experiments, because not only were there fewer interventions, but there were fewer days on which parents were required to administer the hygiene tests, and there were fewer material rewards used to generate the effects. The two aims of Experiment 8 were (i) to examine the importance of material rewards in the Compliance Training contingency, and (ii) to provide further evidence about the efficacy of the refined training package that has been developed during the course of this programme of research.

METHOD

PARTICIPANTS

(a) **Subjects**

A boy (Darren) and two girls (Diane and Justine) were the subjects. Their mean age at the start of the experiment was 5 years 6 months (see Table 5.2.1 for complete subject and sibling details).

(b) **Parents**

Darren's mother, Justine's father, and Diane's mother implemented the procedures throughout the study.

TABLE 5.2.1

AGE OF SUBJECTS AND THEIR SIBLINGS

EXPERIMENT 8

Subject	Age at start	Number of Siblings	Age of Siblings
Darren	5 yrs 9 mths	1	3 yrs
Diane	5 yrs 3 mths	0	-
Justine	5 yrs 5 mths	1	2 yrs

Mean age of subjects = 5 yrs 6 mths

DEPENDENT VARIABLES AND RECORDING

(a) Target Behaviours

The dependent variables were the same as in Experiments 5-7, and data was collected in exactly the same way.

(b) Reliability

The overall Frequency Ratio agreement between the two observers was 94.6% for duration and 95.0% for locations. For Darren agreement was 94.9% for duration and 94.6% for locations; for Diane it was 98.1% and 97.2% respectively; for Justine it was 90.9% and 93.1%. Correlations were: overall, 0.953 for duration, and 0.873 for locations; Darren, 0.903 and 0.956; Diane, 0.991 and 0.782; Justine, 0.966 and 0.881.

EXPERIMENTAL DESIGN

Baselines in this experiment were six days (Darren), nine days (Diane), and twelve days (Justine). After baseline all of the subjects were exposed to the following sequence of three intervention conditions:

(1) Compliance Training without Material Rewards

(2) Compliance Training with Material Rewards

(3) Maintenance of Compliance.

PROCEDURE

Compliance Training without Material Rewards

The Hygiene Tests and the Toothtutor device were introduced simultaneously. On the first day the subject was given a hygiene test, and was informed about the score. After this the parent instructed the child about the use of the Toothtutor (as described in Chapter 3, Experiment 3, Method section), then said:

> *"So remember that you should use the Teddy, and brush every part of all your teeth and gums every night and every morning. I am not going to remind you."*

The parents conducted the hygiene test every evening during this condition, and after each test the child was told her score. If the child had brushed her teeth both in the morning and in the evening, and the hygiene score was above a pre-determined criterion, she was praised. If the child had failed to brush twice, or the hygiene score was below the criterion level, she was not praised, but was given feedback about her behaviour.

Compliance Training with Material Rewards

The token system with the material rewards was introduced in this condition. The procedure was, therefore, the same as that in the 'Hygiene Tests + Compliance Training + Toothtutor' condition of Experiment 6, except that the parents were given more responsibility concerning the implementation of the procedures. No information was given to parents from the video recordings of their children's behaviour and, on the basis of their child's frequency of toothbrushing and hygiene scores, parents were asked to decide when the contingencies should be altered.

Maintenance of Compliance

As in Experiment 6, the instructions and opportunities for gaining material reward were systematically faded. Initially the hygiene tests were conducted after two days, then after three days, and then once a week for the rest of this condition.

Follow-up

The procedure after the Maintenance condition was exactly the same as in Experiment 6, except that in this experiment the period before the first Follow-up condition was nine weeks.

RESULTS

Dental Hygiene

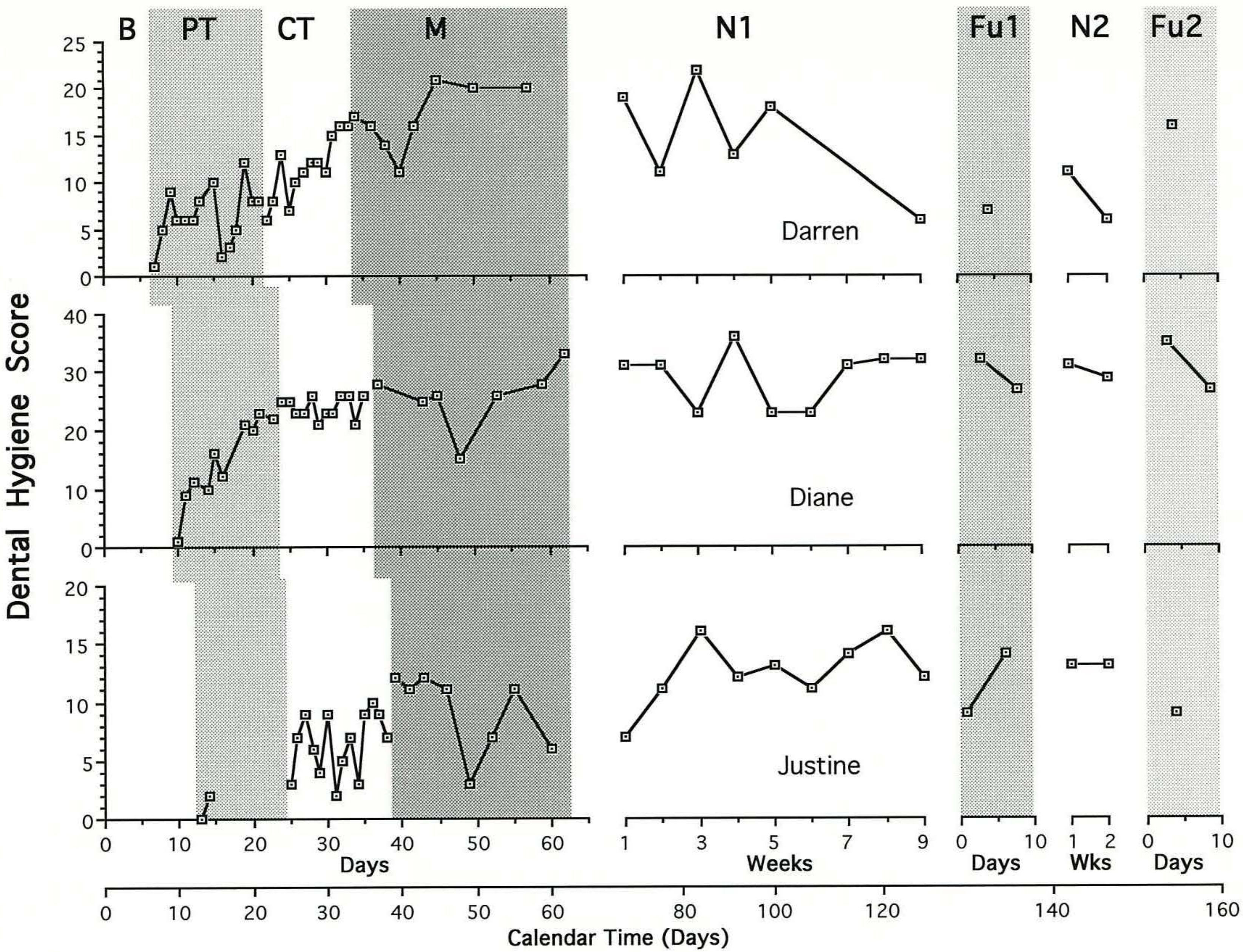
It can be seen from Figure 5.2.1 that Darren's hygiene scores, although variable, increased during the course of the first intervention (PT), his hygiene scores were less erratic and they continued to improve when material rewards were introduced in the next condition (CT), and on average they were even higher during Maintenance (M).

Diane's dental hygiene scores increased rapidly during the first intervention (from 1 to a peak of 23), they remained fairly stable during the second intervention (range, 21 - 26), and remained high during Maintenance (range, 15 - 33).

Justine, on the other hand, refused to take the disclosing agent or allow her father to conduct the hygiene test after the first two days of the first intervention (PT). It was only when rewards were offered, in the second intervention condition (CT), that Justine was willing to co-operate with the hygiene tests procedure. Although her dental hygiene was checked daily during this condition, and this did improve, the scores varied greatly from day to day. Justine's dental hygiene scores were stable and relatively high for the first three tests in the Maintenance condition, but then began to vary as in the previous condition.

Figure 5.2.1

The Hygiene Test scores supplied by each subject's parents during each of the five experimental phases of the study, Hygiene Tests + Toothtutor + Verbal Praise (PT), Hygiene Tests + Toothtutor + Compliance Training (CT), Maintenance (M) and Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it), the 9 week period between Maintenance and the first Follow-up (N1), and the 2 week period between the first and second Follow-ups (N2).



B
PT
CT
M
N1
Fu1
N2
Fu2
Dental Hygiene Score
Darren
Diane
Justine
Days
Weeks
Days
Wks
Days
Calendar Time (Days)

Figure 5.2.1

Darren went on a three week camping holiday five weeks after the end of the Maintenance condition. Up until this time his hygiene scores remained well above the level of scores taken during the first few days of the first intervention. During the holiday, however, his mother did not conduct any hygiene tests, and she reported that Darren's toothbrushing behaviour became infrequent and inconsistent. The hygiene scores taken immediately after the holiday (N1 Day 63 and three subsequent scores) reflect the deterioration in toothbrushing behaviour. The hygiene scores of Diane and Justine were relatively high on each of the occasions that they were recorded during the fourteen weeks following the Maintenance condition.

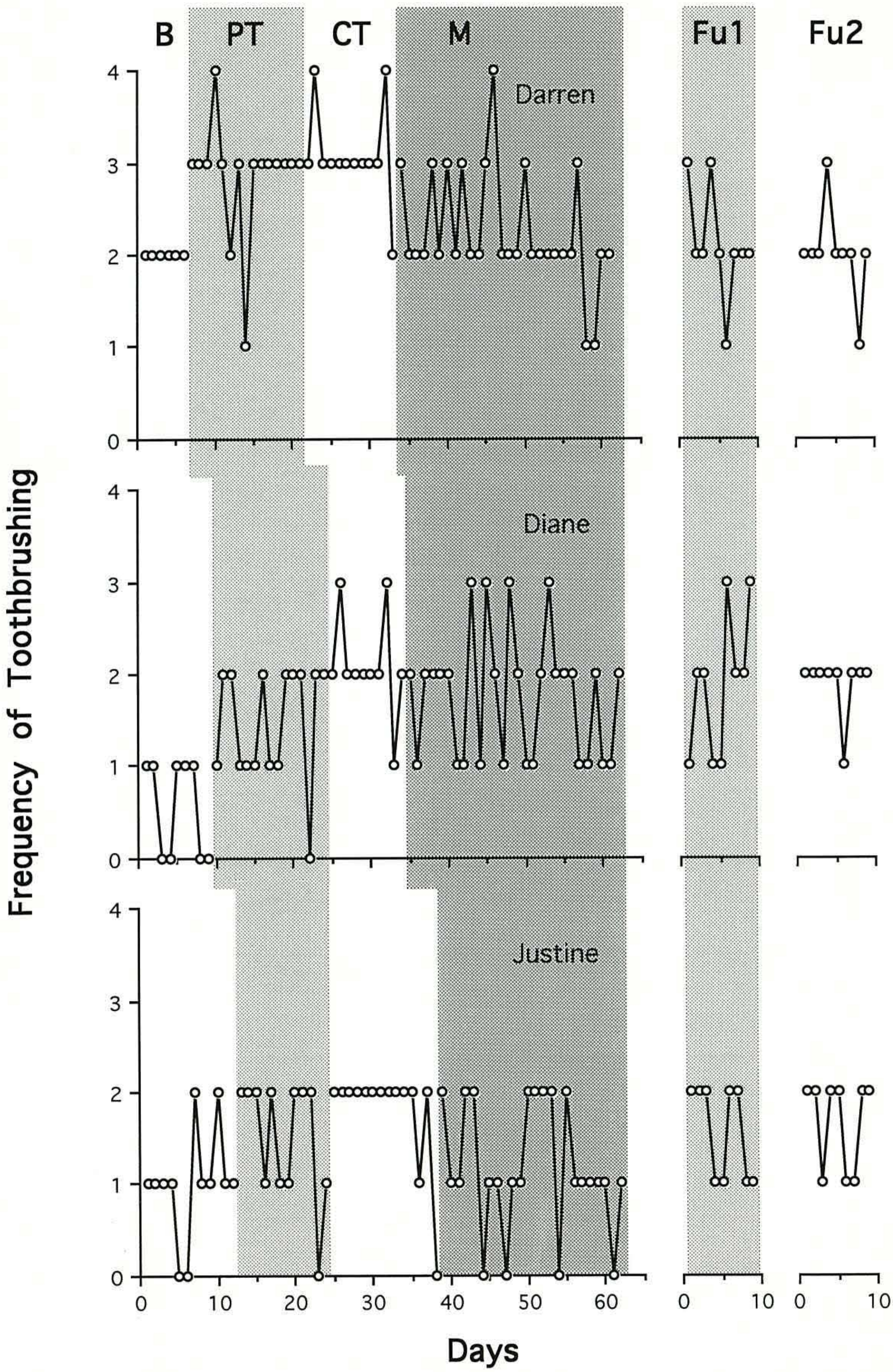
Frequency of Toothbrushing

Figure 5.2.2 and Table 5.2.2 show that although Darren brushed his teeth twice a day every day during Baseline (B), he brushed even more frequently after the introduction of the hygiene tests and the Toothtutor in the first two intervention conditions (PT and CT). Darren brushed three times a day on most days during these conditions, once before the hygiene test, once after it, and once in the morning. In the Maintenance condition (M) Darren usually brushed three times a day on days when there was a scheduled hygiene test, and twice a day on days when there was not. This is also generally true of his behaviour during the Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Figure 5.2.2

Frequency of toothbrushing per day for each subject during each experimental phase: Baseline (B), Hygiene Tests + Toothtutor + Verbal Praise (PT), Hygiene Tests + Toothtutor + Compliance Training (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Figure 5.2.2



B
PT
CT
M
Fu1
Fu2
Darren
Diane
Justine
Frequency of Toothbrushing
Days

TABLE 5.2.2

Mean Frequency of Toothbrushing

Experiment 8

Each subject's frequency of toothbrushing per day, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Hygiene Tests + Praise + Toothtutor (PT), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions					
	B	**PT**	**CT**	**M**	**Fu1**	**Fu2**
Darren						
Mean	2.00	2.87	3.08	2.25	2.11	2.00
Std D	0	0.64	0.52	0.65	0.60	0.50
N	6	15	12	28	9	9
Range	2 - 2	1 - 4	2 - 4	1 - 4	1 - 3	1 - 3
Diane						
Mean	0.56	1.43	2.09	1.75	1.89	1.89
Std D	0.53	0.65	0.54	0.70	0.78	0.33
N	9	14	11	28	9	9
Range	0 - 1	0 - 2	1 - 3	1 - 3	1 - 3	1 - 2
Justine						
Mean	1.00	1.50	1.79	1.17	1.56	1.67
Std D	0.60	0.67	0.58	0.70	0.53	0.50
N	12	12	14	24	9	9
Range	0 - 2	0 - 2	0 - 2	0 - 2	1 - 2	1 - 2
Overall Mean	1.19	1.93	2.32	1.72	1.85	1.85

Diane did not brush her teeth at all at night (and only on five mornings) during the nine days of Baseline. Her mean frequency of toothbrushing per day improved from 0.56 in Baseline to 1.43 in the first intervention condition (PT) and 2.09 in the second (CT). Her frequency fluctuated between once and three times a day during Maintenance. Whenever she brushed three times, it was always on a hygiene test day, and she brushed once before the hygiene test, once after it, and once in the morning. Diane's mean frequency in both two-month Follow-ups was 1.89 times per day, more than three times her Baseline mean.

Although in the first intervention (PT) Justine prevented her father from checking her dental hygiene after the first two days, she improved her frequency of toothbrushing from a mean 1.00 per day in Baseline to a mean of 1.50 in this condition. Justine brushed twice a day on all but two occasions during the Compliance Training condition (CT), and her mean frequency per day was higher during Maintenance and the Follow-ups than it was in Baseline.

Mean Duration of Toothbrushing per Occasion

It can be seen from Figure 5.2.3 and Table 5.2.3 that Darren's mean duration of toothbrushing per occasion was higher on every day of the first intervention phase (PT) than on any day in Baseline, and his overall mean for this condition was 104.40 seconds compared to a Baseline mean of 36.33 seconds. Darren's mean durations per occasion remained high (though a little less stable) throughout the Compliance Training (CT) and Maintenance (M) conditions. His durations per occasion during the Follow-ups were similar to those in Baseline (although slightly higher on average).

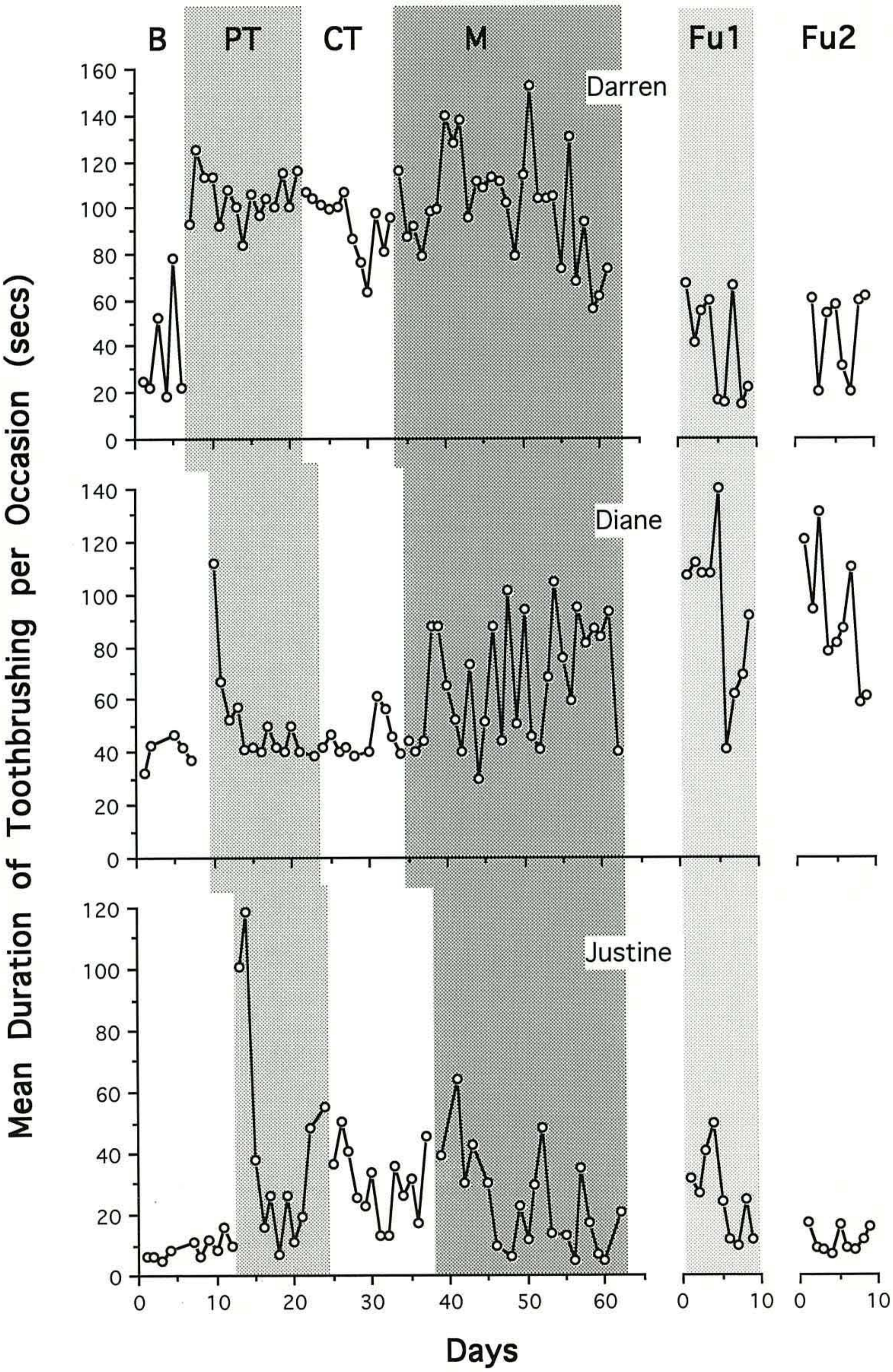
Diane's data are very different. Apart from on the first four days of exposure to the first intervention (PT), her mean durations per occasion per day during the rest of this condition were very like those in Baseline (around 40 to 50 seconds per occasion). This did not change immediately after the introduction of Compliance Training (CT), but her durations of toothbrushing per occasion increased on two days towards the end of this condition (Days 31 and 32). Although more variable in the Maintenance condition (M), Diane's mean durations were generally higher than in any of the previous conditions. Her overall mean duration per occasion was over 90 seconds in both two month Follow-ups (Fu1 and Fu2), higher than in any other condition, and about double the means in the first three phases (B, PT, and CT).

Justine spent very little time brushing her teeth on the occasions that she brushed in Baseline (mean, 8.90 secs). Her mean duration per occasion was 100.5 seconds on the first day and 118.5 seconds on the second day of the first intervention (PT). During the rest of this condition, when she refused to participate in the hygiene tests procedure, her mean durations per occasion were lower than on the first two days, but generally higher than in Baseline. The pattern was similar in the next condition (CT), and in Maintenance and the first Follow-up, when the Toothtutor remained present. Mean durations of toothbrushing per occasion were reduced to Baseline levels in the second Follow-up when the Toothtutor had been removed.

Figure 5.2.3

Mean duration of toothbrushing per occasion per day for each subject during Baseline (B), Hygiene Tests + Toothtutor + Verbal Praise (PT), Hygiene Tests + Toothtutor + Compliance Training (CT), Maintenance (M) and both two month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). These data were calculated by totalling all the recorded durations each day, and dividing this sum by the daily frequency.

Figure 5.2.3



B
PT
CT
M
Fu1
Fu2
Darren
Diane
Justine
Mean Duration of Toothbrushing per Occasion (secs)
Days

TABLE 5.2.3

Mean Duration of Toothbrushing per Occasion

Experiment 8

Each subject's mean duration of toothbrushing per occasion per day, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Hygiene Tests + Praise + Toothtutor (PT), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions					
	B	**PT**	**CT**	**M**	**Fu1**	**Fu2**
Darren						
Mean	36.33	104.40	93.15	101.30	39.85	45.75
Std D	23.99	10.84	13.51	23.89	22.50	18.48
N	6	15	12	28	9	8
Min	18.50	84.00	63.67	56.00	15.00	20.00
Max	78.50	125.00	107.00	153.00	66.67	61.50
Diane						
Mean	40.20	51.69	45.18	66.76	93.09	91.39
Std D	5.81	19.94	7.62	22.90	30.57	25.18
N	5	13	10	28	9	9
Min	32.00	39.00	38.50	30.00	40.67	59.00
Max	47.00	112.00	61.00	105.00	140.00	131.00
Justine						
Mean	8.90	42.32	30.12	23.74	25.89	11.39
Std D	3.44	36.61	11.93	16.56	13.65	4.16
N	10	11	13	19	9	9
Min	5.00	7.00	13.00	5.00	10.00	7.00
Max	16.00	118.50	50.50	64.00	50.00	17.50
Overall Mean	28.48	66.14	56.15	63.93	52.94	49.51

Total Duration of Toothbrushing per Day

Figure 5.2.4 shows the total durations of toothbrushing per day for each of the subjects in each of the conditions. Each data point combines the frequency of brushing per day and the duration of each brushing event that occurred on each day. A clear difference in the data displayed in this figure when compared to that in Figure 5.2.3 can be seen in the case of Diane. Diane did not tend to spend more time brushing her teeth per toothbrushing occasion during the first intervention condition (PT) than she had done in Baseline, but because she brushed more frequently, her total duration of toothbrushing per day was higher on most days. Despite this and other diferences in detail, the same underlying trends seen in Figure 5.2.3 can also be seen in Figure 5.2.4.

It can be seen from Figure 5.2.5 that although Darren and Justine brushed more frequently during the second intervention (CT) than they did in the first (PT), their mean total duration per day was slightly higher in the first intervention. This difference can be attributed mainly to a strong novelty effect immediately after the first introduction of the Toothtutor and the hygiene test procedure. Figures 5.2.3 and 5.2.4 show that these two subjects brushed for much longer on the first few days of the first intervention (PT) than they did during the rest of this condition. If the data from these few days are excluded, the duration levels in the first intervention condition are very similar to those in the second (CT).

Figure 5.2.4

Total duration of toothbrushing per day for each of the subjects during Baseline (B), Hygiene Tests + Toothtutor + Verbal Praise (PT), Hygiene Tests + Toothtutor + Compliance Training (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). Data for this figure were calculated by totalling known durations of all toothbrushing events that occurred on each day.

Figure 5.2.4

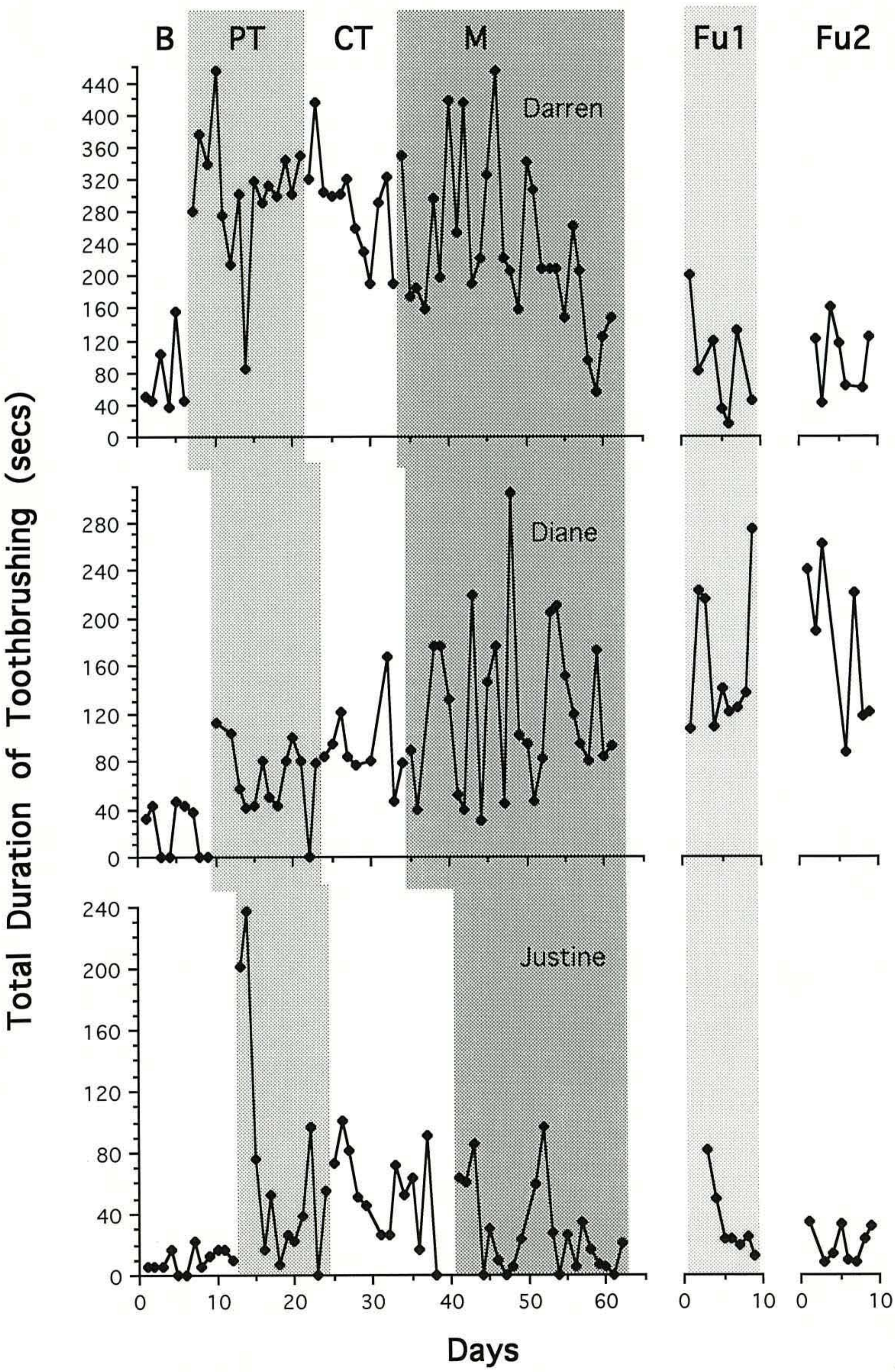
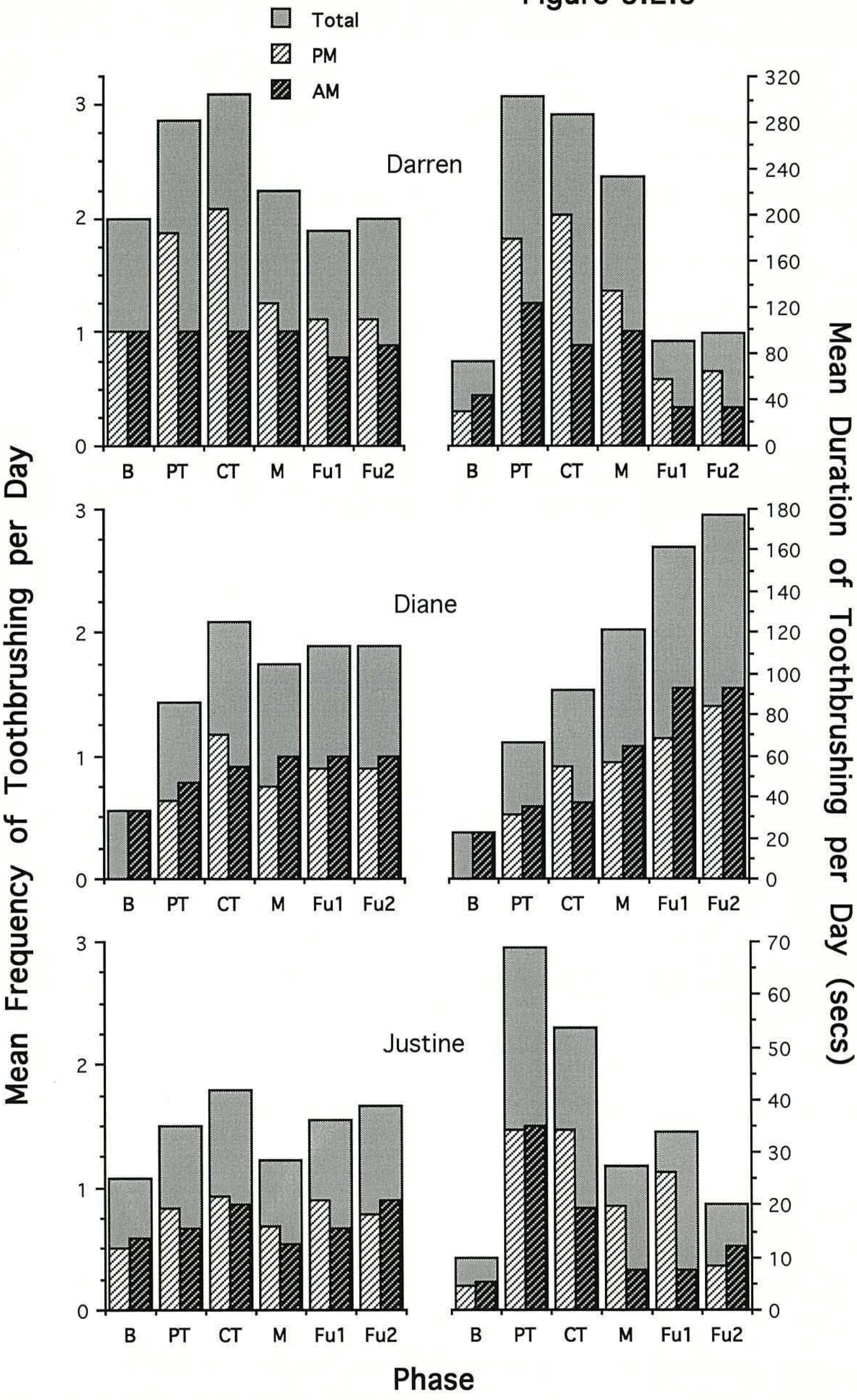

B
PT
CT
M
Fu1
Fu2
Darren
Diane
Justine
Total Duration of Toothbrushing (secs)
Days
0
40
80
120
160
200
240
280
320
360
400
440
0
10
20
30
40
50
60
0
10
0
10

Figure 5.2.5

The mean frequency of toothbrushing per day (left side) and the mean total duration of brushing per day (right side) for each subject in each of the phases. The means for evening (light diagonal line shading) and morning sessions (dark diagonal line shading) in each phase are also shown. Data for the frequency graph (left side) were calculated by totalling the number of brushing events that occurred at night and in the morning, and dividing by the total number of days in the phase. Data for the duration graph were calculated by totalling each subject's known durations at night and in the morning in each phase and dividing by the total number of sessions (of known duration) in the phase.

Figure 5.2.5



Total
PM
AM
Darren
Diane
Justine
Mean Frequency of Toothbrushing per Day
Mean Duration of Toothbrushing per Day (secs)
B
PT
CT
M
Fu1
Fu2
Phase

Diane's performance across conditions was quite different except that, like the other two subjects, her mean frequency per day was highest during the second intervention (PT). Her mean total duration of toothbrushing per day, on the other hand, increased steadily in each phase of the experiment, so that her mean total duration in the second Follow-up (177 secs) was eight times her Baseline mean (22 secs).

Table 5.2.4 shows the percentage difference between the Baseline mean total duration per day, and the means in all the subsequent conditions. Darren's improvement over Baseline was more than 220% in all three intervention conditions (PT, CT, and M), but no more than 35% in the Follow-ups. Justine's percentage increase was even higher during the first two interventions (607% and 451%), and these improvements were much better maintained in the two Follow-ups (247% and 208% respectively). Diane's performance just got better and better, so that although she spent on average 198% more time brushing her teeth in the first intervention (PT) than she had done in Baseline, she spent 693% more time in the second Follow-up (Fu2). Because Diane's data is so different from that of the other subjects, the Overall Mean data is far from being representative of the data from any one subject.

Locations of Toothbrushing

Figure 5.2.6 and Table 5.2.5 show that, as was the case with mean durations per occasion, Darren's mean number of locations brushed per occasion was clearly improved after the introduction of the Toothtutor and the hygiene tests procedure. He brushed the maximum number of locations (16) on many occasions during the three intervention conditions (PT, CT and M). Although Darren's durations of toothbrushing in the two month Follow-ups were not much different to those in Baseline, on average he brushed more locations per toothbrushing occasion in the Follow-ups (means, 10.22 and 12.36 respectively) than in Baseline (mean, 7.42).

Diane tended to brush fewer locations per occasion in the first two interventions (PT and CT) than in Baseline. Her Baseline mean of 10.80 locations per occasion was much higher than that of the other subjects. It may be, therefore, that initially her attempts to follow the Toothtutor interfered with a relatively good strategy for coverage of the dentition that she had learned prior to Baseline. Perhaps it was only after several months of exposure to the device that she was able to master a new strategy for toothbrushing that enabled her to cover more locations of the dentition than previously. She tended to brush more locations per occasion in the two Follow-ups (mean in Fu1 = 12.28, and Fu2 = 11.33), five months after the first introduction of the Toothtutor, than in any previous condition.

Initially Justine, like Diane, tended to improve her mean number of locations of toothbrushing per occasion with successive intervention conditions. In other words, her mean in Maintenance was higher than that in the second intervention, which in turn, was higher than that in the first intervention. However, she brushed fewer locations per occasion in the Follow-ups than in Maintenance, but more on average than in Baseline.

TABLE 5.2.4

Mean Total Duration Difference Scores

Experiment 8

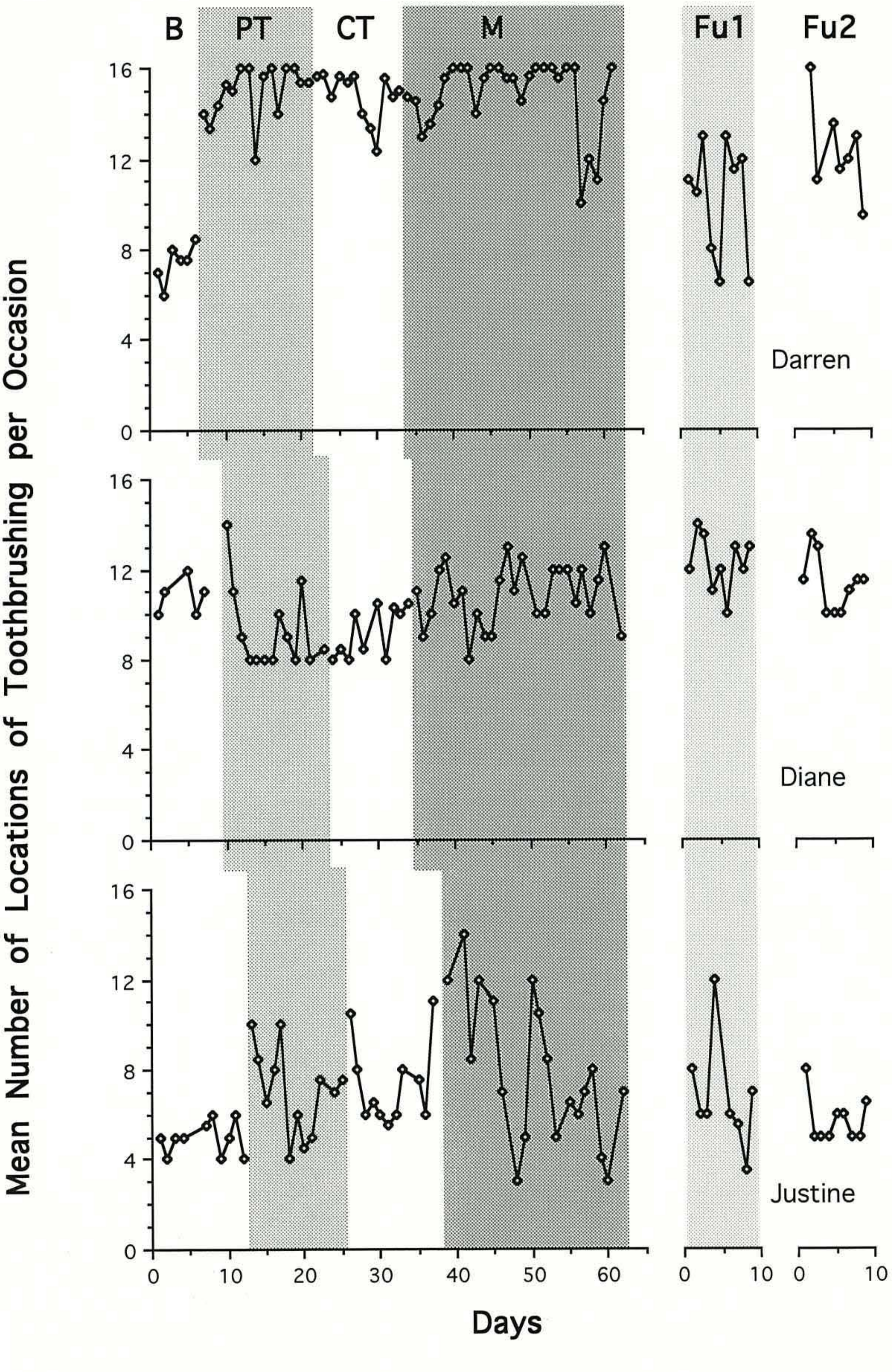
The percentage difference between each subject's Baseline mean total duration per day and his/her mean total duration per day in all subsequent phases: Baseline (B), Hygiene Tests + Praise + Toothtutor (PT), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Sessions	Experimental Conditions				
	PT	**CT**	**M**	**Fu1**	**Fu2**
Darren					
PM	514%	584%	360%	96%	120%
AM	184%	101%	128%	- 25%	- 22%
Total	**316%**	**295%**	**221%**	**24%**	**35%**
Diane					
PM	3008%	5389%	5546%	6722%	8343%
AM	59%	68%	191%	317%	315%
Total	**198%**	**314%**	**444%**	**623%**	**693%**
Justine					
PM	644%	650%	331%	474%	80%
AM	574%	274%	49%	47%	132%
Total	**607%**	**451%**	**182%**	**247%**	**208%**
Overall Mean	**374%**	**353%**	**282%**	**298%**	**312%**

Figure 5.2.6

Mean number of locations brushed per occasion per day for each subject during Baseline (B), Hygiene Tests + Toothtutor + Verbal Praise (PT), Hygiene Tests + Toothtutor + Compliance Training (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it). These data were calculated by adding together the number of locations brushed on each occasion each day, and dividing this sum by the frequency.

Figure 5.2.6



B
PT
CT
M
Fu1
Fu2
Mean Number of Locations of Toothbrushing per Occasion
Darren
Diane
Justine
Days
0
4
8
12
16
0
10
20
30
40
50
60

TABLE 5.2.5

Mean Number of Locations of Toothbrushing per Occasion

Experiment 8

Each subject's mean number of locations of toothbrushing per occasion per day, the standard deviation, number of observations (N), and range (min. and max. values) in each condition: Baseline (B), Hygiene Tests + Praise + Toothtutor (PT), Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Subjects and Measures	Experimental Conditions					
	B	**PT**	**CT**	**M**	**Fu1**	**Fu2**
Darren						
Mean	7.42	14.95	14.81	14.83	10.22	12.36
Std D	0.86	1.19	1.08	1.62	2.59	2.08
N	6	15	12	28	9	7
Min	6.00	12.00	12.33	10.00	6.50	9.50
Max	8.50	16.00	15.75	16.00	13.00	16.00
Diane						
Mean	10.80	9.31	9.23	10.85	12.28	11.33
Std D	0.84	1.85	1.12	1.38	1.25	1.28
N	5	13	10	26	9	9
Min	10.00	8.00	8.00	8.00	10.00	10.00
Max	12.00	14.00	10.50	13.00	14.00	13.5
Justine						
Mean	4.95	7.00	7.38	7.90	6.75	5.72
Std D	0.76	2.05	1.80	3.27	2.48	1.03
N	10	11	12	19	8	9
Min	4.00	4.00	5.50	3.00	3.50	5.00
Max	6.00	10.00	11.00	14.00	12.00	8.00
Overall Mean	7.72	10.42	10.47	11.19	9.75	9.80

DISCUSSION

During the first intervention condition, 'Compliance Training without Material Rewards', the Toothtutors and the hygiene tests with praise for increasing hygiene scores were introduced. However, only two of the three subjects allowed their parents to conduct the hygiene test procedure. Nevertheless, all three subjects increased their frequency of toothbrushing and the improved daily frequency was maintained throughout the 12 to 15 days that subjects were exposed to this condition. During the first few days all of the subjects increased the mean duration of toothbrushing events, and the mean number of locations they brushed on each occasion. Darren maintained the improved behaviour throughout the condition, the other two subjects reduced their mean durations and number of locations back to Baseline levels after three or four days, Justine improved again towards the end of this condition whilst Diane did not. Each subject's mean total duration of toothbrushing per day in this first intervention condition was at least 3 times the mean in Baseline (see Figure 5.2.5 and Table 5.2.4). These results suggest that an intervention that includes parental praise, but no material rewards, contingent upon the child improving his/her dental hygiene can lead to beneficial change in the child's toothbrushing behaviour.

During the second intervention, when the material rewards were introduced contingent upon compliance, all the subjects increased and sustained a frequency of toothbrushing higher than the level of the previous condition. In no case, however, was the mean duration of toothbrushing per occasion higher in the second intervention phase than in the first, and subjects did not brush more locations on each occasion than they had done previously. No firm conclusion can be drawn from the results of this experiment about whether a condition in which children are offered material rewards is more effective than a condition in which they are not. It should be noted, however, that one subject would not participate in the hygiene test procedure before being instructed that if she did so she would have the opportunity to gain material rewards.

The results of Experiment 8 have, however, provided further strong evidence for the effectiveness of the complete Compliance Training package developed in previous experiments. The treatment effects in the Compliance Training condition are comparable to those in corresponding conditions of Experiments 5, 6 and 7. No firm conclusions can be drawn about the long term maintenance effects in Experiment 8 since the data for one of the subjects (Diane) were very different from those for the other two. This experiment also does not provide any evidence about how well the effects would have been maintained if material rewards had never been offered during intensive training, either in a condition immediately after training in which the instructions, hygiene tests, and praise are given only intermittently, or during the two-month Follow-ups. It is possible that such a procedure may produce better long-term maintenance effects than have been seen in the current set of experiments, but further research is needed to assess this possibility.

5.3 GENERAL RESULTS

The data displayed in Figure 5.3.1 are the mean total durations of toothbrushing per day across all subjects in three conditions of Experiments 5 - 8: Baseline (B), Hygiene Tests + Compliance Training + Toothtutor (CT), and Maintenance (M). This figure shows that the training package was extremely effective in all of the last four experiments. When exposed to the Compliance Training condition all of the twelve subjects increased their mean total duration of toothbrushing per day to more than 3 times their Baseline level.

Table 5.3.1 shows that in three of the four experiments the minimum subject mean value for the Compliance Training condition was far greater than the maximum value for any one subject in Baseline (at least 2.5 times greater). This was not the case in Experiment 8, mainly because of the great variation in Baseline means (9.75 - 72.67 secs) compared to the other experiments, but even in this experiment the average difference score between the subjects' Baseline mean total duration per day, and their mean total duration per day during Compliance Training was 353%. All of the twelve subjects spent more than 180% more time brushing their teeth each day in the Maintenance condition than they had done in Baseline, and their average mean total duration per day was 454% above their Baseline level.

Figure 5.3.1

Mean total duration of toothbrushing per day for all subjects in each of three phases in Experiments 5 - 7: Baseline (B), Hygiene Tests + Compliance Training + Toothtutor (CT), and Maintenance (M). The mean data were calculated by totalling each subject's mean total duration per day in each phase and dividing by the total number of subjects in each experiment.

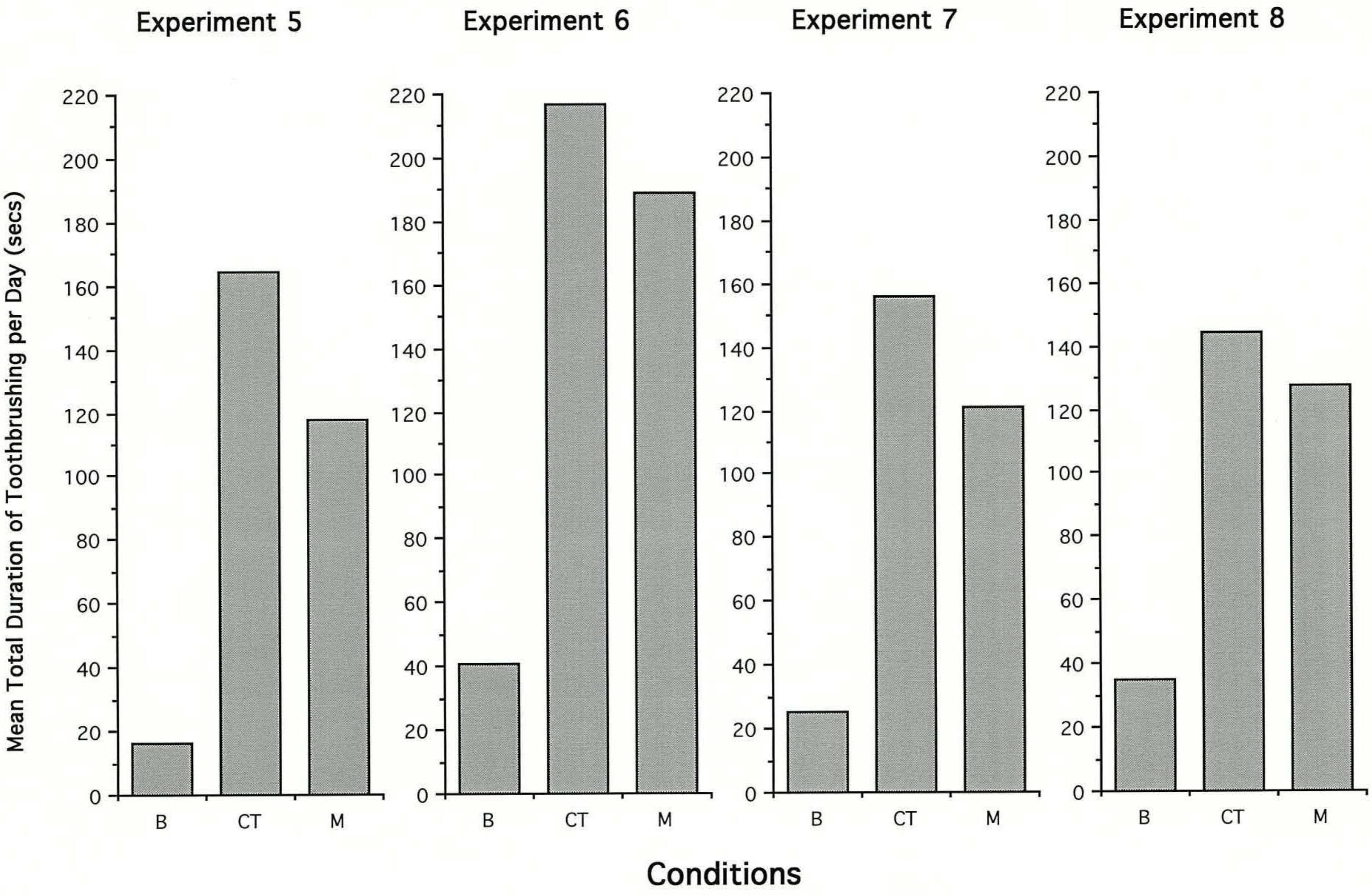

Experiment 5
Experiment 6
Experiment 7
Experiment 8
Mean Total Duration of Toothbrushing per Day (secs)
0
20
40
60
80
100
120
140
160
180
200
220
B
CT
M
Conditions

Figure 5.3.1

TABLE 5.3.1

Mean Total Durations of Toothbrushing

Experiments 5, 6, 7 and 8

The mean total duration of toothbrushing per day, the range (min. and max. values), and the mean difference scores (expressed as a percentage of the mean Baseline durations) across all three subjects in five conditions of each experiment: Baseline (B), Hygiene Tests + Compliance Training + Toothtutor (CT), Maintenance (M) and both two-month Follow-ups (Fu1 - with the Toothtutor; Fu2 - without it).

Experiments and Measures	Experimental Conditions				
	B	**CT**	**M**	**Fu1**	**Fu2**
Experiment 5					
Mean	**16.17**	**164.05**	**117.45**	**62.14**	**32.74**
Min	10.50	117.6	80.29	34.22	7.78
Max	24.00	210.38	151.08	112.88	64.00
Diff Score	-	**1076%**	**755%**	**332%**	**147%**
Experiment 6					
Mean	**40.60**	**216.62**	**188.65**	**95.85**	**84.91**
Min	27.50	172.75	99.40	46.00	18.44
Max	66.00	271.75	278.64	147.00	141.78
Diff Score	-	**540%**	**451%**	**181%**	**108%**
Experiment 7					
Mean	**24.96**	**155.69**	**121.00**	**57.74**	**25.71***
Min	17.50	118.88	91.06	24.50	20.43*
Max	32.83	208.00	140.82	74.57	31.00*
Diff Score	-	**446%**	**326%**	**99%**	**- 2%***
Experiment 8					
Mean	**34.92**	**144.32**	**127.40**	**95.01**	**98.46**
Min	9.75	53.69	27.48	33.86	20.25
Max	72.67	286.83	233.29	161.44	177.14
Diff Score	-	**353%**	**282%**	**298%**	**312%**
Overall Mean	**29.16**	**170.17**	**138.63**	**77.68**	**60.46**
Mean Diff Score	-	**604%**	**454%**	**228%**	**141%**

* Data from only two subjects.

Figure 5.3.2 shows the Baseline mean total durations of toothbrushing per day in each of the experiments compared to the means for the two month Follow-ups, both before and after the removal of the Toothtutor (Fu1 and Fu2 respectively). In all four experiments the mean total duration per day across all subjects in the first Follow-up was at least twice the mean for Baseline. Only one subject (Stuart in Experiment 7) did not spend more time brushing his teeth each day in this condition than he had done in Baseline, and it can be seen from Table 5.3.1 that the average increase in mean total durations per day above Baseline levels was 228%. In three experiments the mean total duration per day across all subjects in the second Follow-up was at least twice the mean for Baseline. Only in Experiment 7 was the mean total duration of toothbrushing per day less in the second Follow-up than in Baseline, but it should be noted that these data come from only two of the subjects. The other subject, Louise, had to be withdrawn because her family emigrated after the first Follow-up condition.

Figure 5.3.2

Mean total duration of toothbrushing per day for all subjects in each of three phases in Experiments 5 - 7: Baseline (B), the two month Follow-up with the Toothtutor (Fu1), and the Follow-up without the Toothtutor (Fu2). The mean data were calculated by totalling each subject's mean total duration per day in each phase and dividing by the total number of subjects in each experiment.

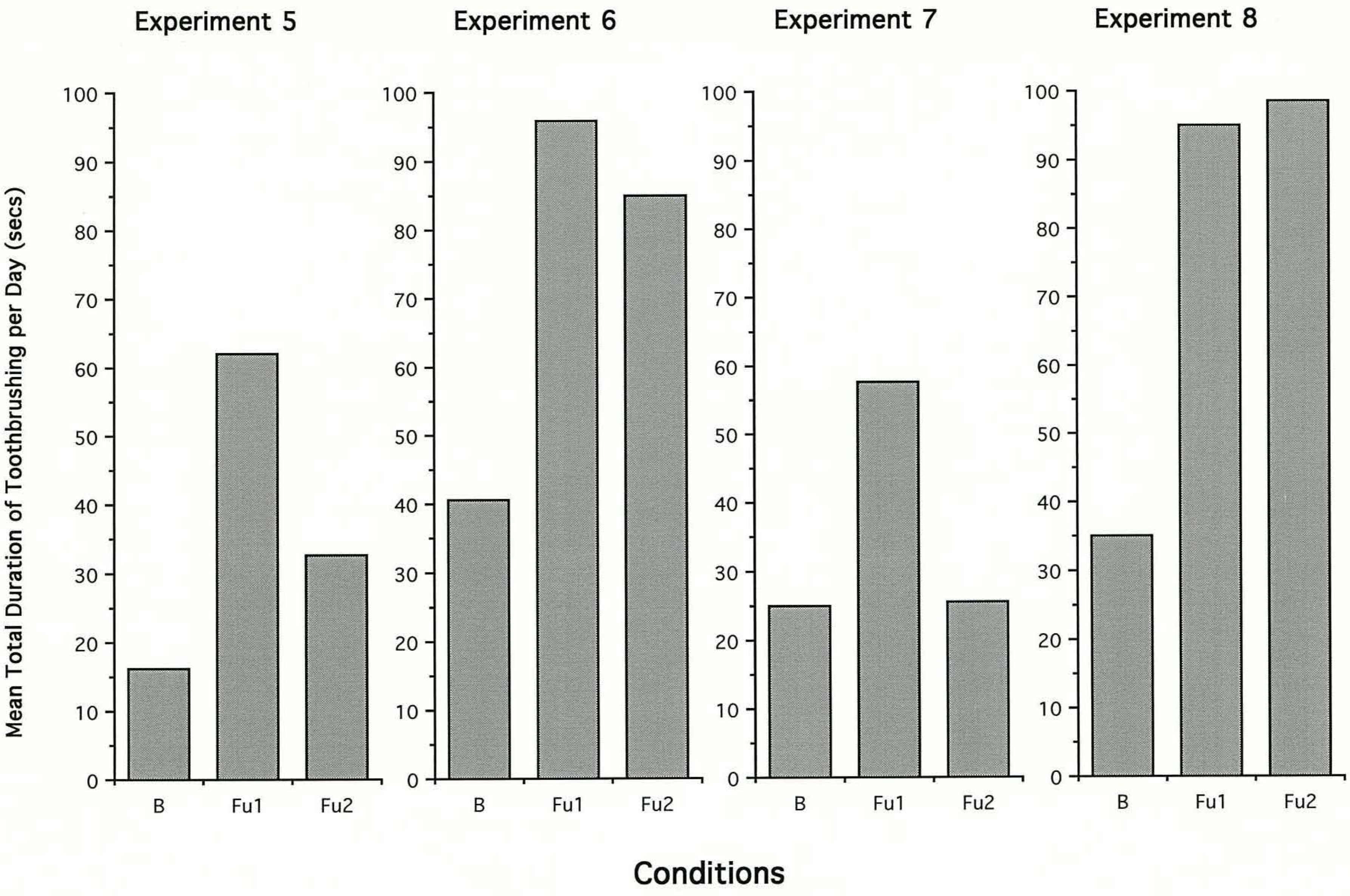

Experiment 5
Experiment 6
Experiment 7
Experiment 8
Mean Total Duration of Toothbrushing per Day (secs)
0
10
20
30
40
50
60
70
80
90
100
B
Fu1
Fu2
Conditions

Figure 5.3.2

5.4 GENERAL DISCUSSION

The last four experiments have demonstrated the effectiveness of a procedure that (i) highlights the level of plaque and dental debris on the surfaces of teeth, (ii) rewards children for brushing frequently and improving their dental hygiene, and (iii) includes a stimulus control device, the Toothtutor. Progressively more 'cost efficient' methods have been examined in these experiments. In Experiment 5, prior to the introduction of the Maintenance condition, the mean number of days of intensive training was 19, the mean number of hygiene tests was 28, and the mean number of days from the beginning of the study was 36. There were fewer intervention conditions in Experiment 6 than in Experiment 5, and thus the Maintenance condition was introduced after a mean of 11 days of intensive training, 25 hygiene tests, and 34 days. There was only one intervention condition prior to the introduction of Maintenance in Experiment 7, thus the mean number of intensive training days was only 8, the mean number of hygiene tests was also 8, and the mean number of days from the beginning of the study was 17. Despite these differences, the results of the Experiments 5, 6 and 7 are remarkably similar.

Experiment 8 examined a different way of enhancing 'cost efficiency'. An intervention that included daily hygiene tests, the Toothtutor, and praise for improving hygiene scores was introduced prior to the complete Compliance Training package. The results in the two conditions were compared and not found to be greatly different, except that all of the subjects brushed their teeth a little more frequently in the second intervention than in the first. One subject also refused to participate in the hygiene tests procedure until the introduction of the rewards in the second intervention. The results suggest that a procedure that includes parental praise (but no material rewards) contingent upon the children improving their dental hygiene can lead to beneficial change in their toothbrushing behaviour. Further research is required, however, to determine whether this procedure would be as effective as one that includes material rewards.

CHAPTER 6

GENERAL RESULTS AND DISCUSSION

6.1. PREAMBLE

The first chapter of this thesis presented, (i) a review of Soviet psychologists' conceptions of verbal regulation and their research on its development in children, (ii) an account of rule-governed behaviour from a behaviour analytic perspective, and (iii) a discussion of behaviour change strategies, such as 'correspondence training', that explicitly incorporate verbal control. The two experiments presented in Chapter 2 addressed a number of theoretical issues concerning rule-governance in correspondence training and a related 'compliance training' procedure. Both methods were designed to improve the toothbrushing behaviour of young children. Chapter 3 examined the effects of incorporating into the compliance training procedure a stimulus control device designed to guide children's toothbrushing. Procedures to provide additional behavioural feedback were introduced in Chapter 4, and the importance of some of the components of the entire behaviour change package was examined in Chapter 5.

This, the final chapter, discusses the results of the eight experiments in relation to one another and within the broader context of behaviour analysis. In Section 6.2, the results of the first four experiments are considered. In Section 6.3, concepts of verbal regulation and of different kinds of rules are discussed as means of interpreting these results. Section 6.4 discusses the results of Experiments 5-8, and Section 6.5 is a discussion of theoretical issues surrounding the problems of maintenance of behaviour change arising from these experiments. Finally, Section 6.6 considers the practical implications of the current research, particularly within the domain of dental care, but also for children's behaviour in general.

6.2. OVERVIEW OF RESULTS: EXPERIMENTS 1-4

Experiment 1 showed that a 'say-do' correspondence training paradigm may be usefully employed by parents in their family home to promote the frequency and duration of children's toothbrushing. Each afternoon (generally after school but before the evening meal) during training the children were prompted to say *"Every night and every morning, I will brush every part of all of my teeth and gums"*, and when rewards were made contingent upon both stating this rule and brushing twice each day, the children brushed more frequently at night and in the morning, even though they were not given feedback or rewards for their behaviour until the following afternoon. They did not, however, increase their durations of toothbrushing until a contingency was explicitly placed on stating the toothbrushing rule, brushing twice a day, and increasing the duration of each toothbrushing event. The improved behaviour was well maintained during a phase (Maintenance) when the experimenter-imposed contingencies were systematically faded out. Two months later, in a Follow-up (baseline) condition, subjects generally brushed their teeth more frequently and for longer than they had done in Baseline.

In Experiment 2 subjects were never required to 'say about doing'. Instead, during a Compliance Training intervention, parents simply instructed their children (in the afternoon, generally after school but before the evening meal) to *"brush every part of all teeth and gums every night and every morning"*. When rewards were made contingent upon the subjects brushing twice a day they increased their brushing frequency. The same instruction with a contingency on both frequency and duration of toothbrushing led to clear improvements in brushing durations in all cases. These improvements were well maintained when the experimenter-imposed contingencies were faded out in the Maintenance condition, and performance during the two-month Follow-up was much better than in the initial Baseline phase.

The results for both frequency and duration of toothbrushing from Experiments 1 and 2 were so similar in each respective condition (Correspondence/Compliance Training, Maintenance, and Follow-ups) that, on the basis of these experiments, one method cannot be said to be more effective than the other (see Figure 2.5.1). These results provided strong support for a proposal put forward by previous researchers (Baer, Detrich & Weninger, 1988; Deacon & Konarski, 1987; Weninger & Baer, 1990), that "an overt verbalization by the child may not be a controlling variable in the typical correspondence training paradigm" (Baer, Detrich & Weninger, 1988, p.355). The first experiment demonstrated that correspondence training is effective even when (i) the instructions refer to two separate temporal contexts for behaviour, and (ii) during training there is a time delay of at least 14 hours between 'saying about doing' and the second instance of 'doing'. The second experiment showed that another method, 'compliance training', that does not require the subjects to 'say about doing', but provides them with adequate verbal instructions about the contingencies, can alter behaviour as effectively as correspondence training.

Although toothbrushing behaviour was substantially improved by the procedures employed in Experiments 1 and 2, it was noted that (i) further increases in duration were required to reach the criterion level recommended by dentists (see Thaller, Reiser & Ward, 1972), and (ii) children did not brush all areas of the dentition adequately. The primary aim of Experiment 3 was to investigate the possibility of gaining further control of children's toothbrushing by incorporating a stimulus control device (the "Toothtutor") into the compliance training procedure. This device provided a visual and temporal guide for the children, showing where to brush and for how long to brush each area. Compliance training, rather than correspondence training, was adopted for further investigation in this experiment, since it involved fewer components and was easier for parents to conduct. The results showed that the introduction of the Toothtutor promoted large increases in (i) the amount of time children spent brushing their teeth, and (ii) the number of locations (tooth surfaces) brushed.

Experiment 4 was conducted to (i) examine whether the Toothtutor alone would be effective without the Compliance Training contingency, and (ii) provide further evidence about the efficacy of a procedure that includes both the Toothtutor and compliance training. The results of this experiment showed that introducing the Toothtutor alone led to immediate increases in frequency, duration, and number of locations of toothbrushing, but this was followed by a marked deterioration in all three measures after just three or four days. Only after the introduction of the Compliance contingency were the improvements in behaviour regained and maintained.

During the Compliance Training + Toothtutor conditions of Experiments 3 and 4, each of the six subjects' mean duration of toothbrushing per occasion was close to 90 seconds (overall mean = 88.98 secs), and in all cases the mean total duration per day was more than 237% higher than it was in Baseline. During the first two-month Follow-up (with the Toothtutor still in place) all of these subjects spent, on average, at least twice as long brushing their teeth per day as they had done in Baseline, but in many cases the mean total duration was only half the level seen during training. Performance during a second Follow-up (after the removal of the Toothtutor), although usually superior to performance in Baseline, was often considerably worse than in the training phases and the first Follow-up (see Figures 3.1.7 & 3.2.4).

6.3. RULES AND THE VERBAL REGULATION OF BEHAVIOUR

The results of the experiments reported in this thesis cannot easily be understood without recourse to the concept of verbal regulation. It is not conceivable that, without language, children could have learned to alter their behaviour so immediately and dramatically in two separate temporal contexts (at least 2 hours and 14 hours after the intervention) when rewards were given up to 22 hours after the evening toothbrushing, and 10 hours after the morning toothbrushing (24 hours after instruction). The effects of the interventions were clearly dependent on instructions as well as contingencies of reinforcement, and thus can be interpreted in terms of rule-governed behaviour. How well the effects were maintained can be interpreted in terms of the transfer of control from 'pliance' to 'tracking' (Zettle & Hayes, 1982).

The research reviewed by Luria (1961) showed that (i) what is formulated in language carries a special power to influence the behaviour of young children; (ii) from obeying the verbal instructions of an adult, children go on to instruct themselves in words, both directly and indirectly; and (iii) for children to say what they plan to do increases the probability that they will persist and complete the undertaking; (iv) in short, language performs a regulative function.

> "Connections which were previously elaborated gradually, which needed permanent reinforcement and were extinguished when it was

removed, begin now to be elaborated quickly, sometimes 'on the spot', become stably reinforced, cease to be in need of permanent reinforcement and begin to show those features of 'self regulation', which Pavlov regarded as the essential peculiarity of human higher nervous activity." (Luria, 1959, p.30).

Pavlov described language as the "second signalling system", and asserted that people share with other animals the "first signalling system" (i.e. direct interaction with the environment), but that the second is exclusive to humans. It consists of signals of the first signals, and according to Pavlov, it allows a person to regulate his own behaviour to a degree not known in the rest of the animal kingdom. Pavlov (1927) pointed out, however, that "it cannot be doubted that the fundamental laws governing the activity of the first signalling system must also govern that of the second, because it, too, is activity of the same nervous tissue." In other words:

"language, the accomplishment that frees so much of human behaviour from direct environmental control, [is] itself affected by its consequences. So it turns out that even at the level of consciously controlled behaviour we cannot leave out of account conditioning, though we must acknowledge, of course, that many of the most effective consequences for human action are culturally established." (Lowe, 1989, p.25).

The establishment of normative rules (Reese, 1989) and the maintenance of rule-following (Hayes, Zettle & Rosenfarb, 1989) are subject to contingencies just as any other behaviour. The distinguishing feature of rule-governed behaviour, however, is that the behaviour referred to in the rule is governed not only by its consequences, but also by the rule (see Skinner, 1969).

> "Rule-governed behavior involves two distinct sets of contingencies. One set of contingencies involves those related directly to the behavior of interest. The second set is verbal and somewhat independent of the first......... Thus, it is self-awareness, or contingencies about contingencies, that are the essential requirements for rule-governed behaviour" (Zettle & Hayes, 1982, p.78).

In addition to the verbal contingency on rule-following (that establishes the behaviour), responding will normally produce other *collateral* consequences (Cerutti, 1989). For example, compliance with a teacher's instruction to write structured computer programmes may be reinforced by the teacher's approval, but another consequence is that structured programmes are easy to read, debug, and modify.

> "These consequences are produced after the behaviour is generated, and they can be considered *collateral consequences* in the sense that they accompany instructional consequences, and that their role in determining the initial form of responding is minimal." (Cerutti, 1989).

In the current research, although the instructions during the training phases referred to the natural consequences of effective toothbrushing (i.e. *"to keep your teeth healthy and clean")* it was made apparent to the subjects that socially mediated consequences would be delivered contingent upon rule-following.

The changes in behaviour, therefore, are attributable (at least partially) to pliance. In other words it is likely that the rule generated and followed by the subjects was one about receiving material rewards from the instruction-givers (rather than keeping teeth healthy and clean). The problem with pliance is that it is entirely dependent on 'socially mediated' consequences. As soon as it becomes apparent to the subject that the instruction-giver (parent) is no longer delivering these consequences contingent upon rule following, then the behaviour will cease unless the behaviour becomes in some way self-reinforcing or other sources of reinforcement are tapped.

In the first four experiments of the current research, behaviour was maintained at above Baseline levels during the two-month Follow-ups, but the mean total durations of toothbrushing per day were often less than half the values seen during training. Because behaviour change was maintained to some extent after the experimentally imposed contingencies had been faded out, it appears that the children's behaviour did make contact with some other source of reinforcement, but whatever this was, it was less reinforcing than the 'socially mediated' consequences provided during training (see Premack, 1959,1965).

Malott (1988) suggests that often a reason why many people have trouble following health rules (like daily toothbrushing) is that the consequences of rule-following are small and of only cumulative significance. Malott posits "two types of indirect-acting contingencies - those described by rules that are easy to follow and those described by rules that are hard to follow" (1988, p.186). In his analysis *"To keep my teeth healthy and clean I will brush every part of my teeth and gums every night and every morning"* would be a hard-to-follow rule, since for a contingency to be effective, the consequences "must be immediate, probable and sizable" (1989, p.269), and the natural consequences of toothbrushing (e.g. a reduction in the amount of dental disease) are delayed and small (of only cumulative significance).

According to Malott, in order to control behaviour, hard-to-follow rules "need the support of a rule describing an additional contingency; and that rule must be of the easy-to-follow variety" (1988, p.186). Indeed, conceptualized in Malott's terms, it could be said that during training in the first four experiments an easy to follow rule, a ply (*"To get the present I must brush my teeth tonight and tomorrow morning"*), supported a difficult-to-follow rule, a track (*"To keep my teeth healthy and clean I must brush my teeth every night and every morning"*). The additional contingency was faded out in the Maintenance condition, and during Follow-up, only the difficult-to-follow track was left to control behaviour, thus accounting for the difference in effects during the various conditions.

6.4. OVERVIEW OF RESULTS: EXPERIMENTS 5-8

In the last four experiments parents were taught to score subjects' dental hygiene using a disclosing agent and a modified version of the *Plaque Control Record* (O'Leary, Drake & Naylor, 1972). Parents learned to conduct the plaque assessments with very little tuition, and scoring was shown to be accurate when tested on a model at various times during the experiments. Dental hygiene was included as an additional dependent variable in Experiments 5-8, but because the reliability of subjects' hygiene scores provided by their parents was never checked, these were not considered a robust and reliable measure of the effects of the interventions (see Chapter 4 Section 4.1 for a more complete explanation).

Because the disclosing agent highlighted the presence or absence of plaque by colouring it red, and because the assessment tests provided regular quantification of dental hygiene, the natural consequences of toothbrushing were made more immediately and frequently apparent. Hygiene tests were conducted daily during training, presentations were reduced to once a week in the Maintenance conditions, and these weekly presentations continued until the end of the Follow-ups. It was hypothesized that this procedure might promote better long-term maintenance effects than were seen in the earlier studies, because it made the consequences of tracking more immediate and sizable.

In Experiment 5 the video camera evidence concerning the durations and number of locations brushed per toothbrushing event was *never* made known to the parents. Instead, they recorded hygiene scores for their children at the pre-determined times, and they monitored daily the frequency of subjects' toothbrushing (but were told not to remain present when the children were brushing their teeth). After Baseline, in the Hygiene Tests condition, parents conducted the plaque assessments daily, but gave their children no feedback about their dental hygiene. This led to an increase in children's frequency of toothbrushing, particularly at night immediately after the tests. In the next condition, Compliance Training, parents told their children that in order to gain rewards they should brush twice each day and improve their dental hygiene (measured daily). This led to further increases in brushing frequency (both at night and in the mornings), and an average increase in total toothbrushing durations per day of 264% above Baseline. The children did not, however, increase their mean durations of toothbrushing per occasion, nor the number of locations that were brushed. Only when the Toothtutor was introduced into the Compliance Training package was there a substantial increase in mean durations and number of locations brushed per occasion. The performance of subjects in this condition was comparable to that of subjects in the Compliance Training + Toothtutor condition of Experiments 3 and 4 (see Figure 4.1.8), indicating that even without direct access to their children's behaviour (the video recorded data) parents were able to implement procedures that led to substantial improvements in durations and number of locations of toothbrushing.

Dental hygiene scores improved with the introduction of each intervention, they remained high during Maintenance and for a further three month period (when hygiene tests were conducted only once a week) until the end of the second Follow-up. Contrary to expectations, however, the procedures implemented in Experiment 5 did not lead to better short or long-term maintenance of *behaviour* change when compared to the results of previous experiments (see Table 4.1.6).

A possible reason for this finding may have been that subjects were able to fulfil the requirements of the contingency (brushing twice a day and maintaining a 'good' hygiene score) without maintaining long durations of toothbrushing. An attempt to remedy this was made in Experiment 6. That is, parents of subjects who participated in Experiment 6 were taught to make finer discriminations of the presence of plaque on each tooth surface than the parents of the children in Experiment 5. In other words, it was made more difficult for children to gain a 'good' hygiene score. Another modification in Experiment 6 was that instead of simply telling subjects whether their hygiene score was 'good' or 'bad', parents told them their 'score' (number), and this was written on a calendar kept in the bathroom. The children were told that their aim should be to make the number 'bigger'.

Higher durations during training (mean = 107.39 seconds per occasion), and better maintenance effects after the removal of the Toothtutor were seen in Experiment 6 than during any previous experiment (see Figure 4.2.7). Despite the high durations, subjects' hygiene scores did not improve as rapidly as those of subjects in Experiment 5. This suggests that the subjects in Experiment 6 needed to brush each tooth surface more thoroughly (for longer) than subjects in Experiment 5 to have it scored as "clean", and this may have been an important factor determining the maintenance of higher durations in Experiment 6. However, because there were other important differences in procedure between Experiments 5 and 6, the relative contribution of each could not be independently determined (see Chapter 4 Section 4.2 for details).

Taken together, the results of Experiments 5 and 6 suggest that improvements in children's toothbrushing behaviour leads to improvements in their dental hygiene. Experiment 6 has shown that children can learn to spend regularly a full two minutes brushing their teeth twice each day without explicit prompts or assistance from their parents. Long-term maintenance, however, remains an issue because, although most of the children in Experiments 3 - 6 tended to spend more time brushing their teeth during the two-month Follow-ups (both with and without the Toothtutor) than they had done in Baseline, no subject has yet spent as much time brushing during the Follow-ups as during training.

The procedure implemented in Experiment 7 differed in three important ways to that of Experiment 6. First, the number of intervention conditions was reduced: Compliance Training and the Toothtutor were introduced on the same day as the first hygiene test (rather than several days later as in Experiment 6).

Second, an attempt was made to reduce the number of days that subjects were exposed to a continuous reinforcement condition. In Experiment 6 the Compliance Training + Toothtutor condition continued for at least nine days before the introduction of Maintenance. The minimum duration for this condition in Experiment 7 was set at four days, but because of the pre-set criterion of three consecutive days of brushing twice a day and improving hygiene scores, only one of the three subjects was actually exposed to the Compliance Training condition for less than nine days. Third, the Maintenance condition was longer than in any previous experiment.

The results of Experiment 7 were very similar to those of Experiment 6 in each of the respective conditions (see, for example, Table 5.1.7), suggesting that a condensed version of the refined training package, that includes just two intervention conditions (Compliance Training + Toothtutor, and Maintenance), can be used to improve the toothbrushing behaviour of young children. The procedure was more 'cost efficient' than those used in previous experiments, because not only were there fewer interventions, but there were fewer days on which parents were required to administer the hygiene tests, and there were fewer material rewards used to generate the effects. There is no evidence, however, that this procedure enhanced long-term maintenance any more effectively than previous procedures.

Experiment 8 was designed to (i) examine the effects of a Compliance Training procedure that did not include material rewards in the contingency, and (ii) provide further evidence about the efficacy of the refined training package. The Toothtutors and daily hygiene tests were introduced immediately after Baseline, and children were praised for complying with an instruction to brush their teeth twice each day and improve their dental hygiene. Only in the second intervention condition were material rewards introduced contingent upon compliance. The procedures during this and following conditions (Compliance Training + Toothtutor, Maintenance and Follow-ups) were the same as those in Experiment 6 and 7.

One of the three subjects refused to allow her parents to conduct the hygiene test procedure until the introduction of the rewards in the second intervention condition, and all of the subjects brushed their teeth a little more frequently in the second intervention than in the first. Despite these differences, however, the subjects' total durations of toothbrushing per day, and the number of locations brushed per occasion, were not greatly different in the two conditions. This result indicates that a procedure that includes parental praise (but no material rewards) contingent on the children improving their dental hygiene can lead to beneficial change in their toothbrushing behaviour. However, it cannot be determined without further research whether such a procedure would be as effective as one that includes material rewards, and whether it would promote better maintenance effects. This task may be aided by first performing functional analyses to determine the relative 'reinforcing values' of different forms of 'praise' and material rewards in a relevant context.

6.5. RULES AND THE MAINTENANCE OF BEHAVIOUR CHANGE

The Follow-up data show that subjects' performances in the last four experiments were not greatly superior to those in the first four, and so the issue of how to promote better long-term maintenance of treatment effects remains unresolved. Despite the decline in toothbrushing behaviour two months after the removal of the experimenter-controlled contingencies the dental hygiene levels (recorded by parents) remained high. This appears to indicate that once dental hygiene has been improved (by increased toothbrushing) the level of toothbrushing required to maintain low plaque levels is less than that required to induce the initial reduction. If this is true, it may be that, although two previous studies have reported maintenance of improved plaque levels several months after initial interventions (Baer, Blount & Stokes, 1987; Swain, Allard & Holborn, 1982), the improvements in toothbrushing *behaviour* may not have been so well sustained. It is not yet clear what level of behaviour is required for optimal dental hygiene, but for the science of behaviour analysis, it is important to determine how changes in behaviour can be optimally maintained.

Stokes and Osnes (1989) suggest, in a paper entitled *An Operant Pursuit of Generalization,* that "In general, clinicians and researchers would do well to implement and analyse procedures that follow the generalization programming principles of exploiting current functional contingencies, training diversely, and incorporating functional mediators" (p.337). They outline a number of specific strategies which they recommend as likely to facilitate the occurrence of generalization and maintenance in programmes of clinical importance. Some of the maintenance strategies they advocate have been employed in the current research, for example, "recruit natural consequences", "make consequences less discriminable", and "incorporate functional mediators". These and other recommendations are discussed in the remainder of this section.

The dangers of introducing "powerful operant contingencies" in applied settings has been pointed out by Remington (1991, pp.6-8), who suggests that "the very power of the added contingencies may well overwhelm those responsible for the maintenance of target behaviours." Consonant with the Stokes and Osnes (1989) suggestion to "exploit current functional contingencies", Remington argues for the practice of functional analysis prior to intervention, and warns that "even successful interventions leave questions regarding the variables previously controlling target behaviours unanswered. This involves more than intellectual dissatisfaction with lack of complete understanding; the unexamined variables may reassert control, resulting in a failure to produce generalized and lasting behavioural change."

It is true that powerful operant contingencies were introduced during each of the experiments described in this thesis. However, since the level of toothbrushing during the Follow-ups was generally higher than in Baseline, there is no evidence to suggest that these experimentally imposed contingencies obliterated the effects of contingencies that previously controlled toothbrushing. It may be, however, that an analysis of the variables controlling other behaviours, that are incompatible with toothbrushing, may have revealed a more effective maintenance strategy.

In any given setting an individual must choose from a number of competing concurrent operants. The most straightforward way to alter the frequency of a target response is to increase the frequency of reinforcement for that response, but the frequency of the target behaviour will also be affected by the reinforcement available for the competing concurrent operants (Schull & Fuqua, 1993). There are numerous competing contingencies that may gain control of children's behaviour at the times when they should brush their teeth (e.g. watching TV, playing with toys or siblings etc.). One approach to enhancing maintenance might be to incorporate into the procedures a story book, involving toothbrushing, and a game that could be played with siblings and other members of the family. The players' object in the game might be, for example, to save the teeth from 'bad guys' such as 'Jack Plaque', 'Dan Decay' and the 'Sugar Sisters'. The game could be arranged so that players move their counters on a playing board a certain number of spaces, depending to their hygiene score. As the players increase their scores the 'bad guys' are slowly defeated. Such a game might encourage self-monitoring, and by providing a different kind of motivation (that is, 'winning the game'), it may decrease dependence on material rewards, and parental control, thus enhancing *self*-control.

The current research has focussed mainly on manipulations of (i) verbal instructions and (ii) the *consequences* of behaviour. The Toothtutor, however, provided visual and auditory *antecedent* cues to guide the children's behaviour once toothbrushing had begun. Its introduction always led to increases in both durations and number of locations of toothbrushing, but its placement in the bathroom limited its effectiveness as a cue to *begin* brushing. Assuming that "behavior is never undetermined, that all responses are controlled, if not by the stimuli the experimenter has specified, then by others" (Sidman, 1980, p.286), Kirby and Bickel (1988) point out that maintenance effects depend not only on the principle of reinforcement, but also on *stimulus control*. In view of all the possible competing contingencies that could have gained control of the children's behaviour in the current studies, it is likely that the frequency of toothbrushing may have been more uniformly maintained if more consideration had been given to events that cue rule-following (toothbrushing) at appropriate times.

In keeping with the general strategy of the current research to promote 'self-control', subjects' parents were asked not to prompt their children to brush their teeth during the Baseline and intervention conditions. Prompting, however, was not controlled during the eight weeks between the intervention phases and the Follow-ups. Discussion with the parents indicated that the amount and type of cues they provided varied from simple statements like, 'It's time to get ready for school', or 'It's time for bed', to 'Go and brush your teeth. Make sure you do them properly'. Some parents were often present when the subjects brushed their teeth, others were not. Dependency on parent-provided antecedent cues may be minimized by giving subjects watches with alarms that sound at times appropriate for toothbrushing - a strategy in keeping with the suggestion to "incorporate common salient physical stimuli" (Stokes & Osnes, 1989). An alternative would be to give instructions that explicitly pair toothbrushing with other behaviours that must take place every day at appropriate times. For example, one such instruction might be "whenever you put on (take off) your pyjamas remember to brush your teeth."

Not only the antecedent cues provided by parents, but also their reactions to their children's toothbrushing behaviour varies within and between families. Some parents maintain keen emphasis on good toothbrushing, and respond positively when their child's teeth are brushed well; others pay little attention to brushing behaviour. As the behaviour of the parents is likely to be a major controlling variable that influences children's toothbrushing in most 'normal' households, it could be argued that future strategies to programme maintenance should, instead of attempting to minimize parental influence, aim to standardize 'good' parental practices.

Prior to the introduction of the interventions in the current research, when the children's toothbrushing was poor, their behaviour did not set the context for parents to provide positive social consequences for 'good' toothbrushing. After the interventions, when the children's toothbrushing had improved, parents had more opportunity to react positively and praise their children's behaviour. Parents' reactions to their children's toothbrushing was not systematically controlled in the period between Maintenance and Follow-ups, and is known to have varied between families. It is possible that this variability may account for some of the variability in the Follow-up data, and better maintenance may have been seen if training had focussed more on parental behaviour, teaching them to provide effective antecedents and consequences designed to maintain their children's behaviour.

The introduction of the disclosing agent and the hygiene test procedure can be viewed as an attempt to "recruit natural consequences" (Stokes & Osnes, 1989), because it made the natural consequences of toothbrushing more immediately and frequently apparent. Another approach of this sort would be to more actively 'augment' the sensory consequences of toothbrushing. When the Toothtutor was introduced in Experiments 3 - 8, the children could have been encouraged more to feel with their tongue how clean their teeth were after brushing thoroughly, and more could have been made of the difference between the "horrible sticky feeling" of dirty teeth compared to the "lovely smooth feeling" teeth that are clean. According to Hayes, Zettle and Rosenfarb (1989) "An augmental is a verbal stimulus that also functions as an establishing stimulus." The presentation of an establishing stimulus alters the reinforcing or punishing status of other stimuli. Instructing children to attend to the sensations in their mouth before and after toothbrushing, and then to label these sensations with emotive words may alter the function of oral stimuli (see Schlinger, 1993). Such a procedure might enhance maintenance by providing additional immediate and predictable consequences for toothbrushing.

Malott (1989) stresses that, in order to control behaviour, a contingency must include consequences that are "immediate, probable and sizable". He argues that in the absence of observable reinforcers that are immediately available, we must infer that human operant behaviour is reinforced by private events like "automatic and self-given behavioural consequences such as feelings and thoughts" (p.294). Stokes and Osnes (1989) advocate incorporating "self-mediated verbal and covert stimuli" as a method of programming maintenance. Malott (1989, pp.292-294) suggests four general types of self-given covert statements that may act to maintain control by rules:

(1) *Rewarding thoughts (self-statements) about our following a rule:* for example, "I did well to do what I said I would." Such rewarding thoughts might deal only with compliance and involve no reference to the natural outcome of following the rule.

(2) *Aversive thoughts about our failure to follow the rule:* for example, "I did a really poor job of toothbrushing this morning when I was told to always brush them well." Again no reference is made to the natural outcome of following the rule.

(3) *Rewarding thoughts about how our current actions are leading toward the accomplishment of the outcome stated in the rule:* for example, "I brushed really well today, and if I do this every day, I will get a 'big' score the next time mummy checks my teeth."

(4) *Aversive thoughts about how our current actions are not leading toward the accomplishment of the favourable outcome:* for example, "If I don't brush my teeth before I go to school, I'll get a bad score when mummy checks my teeth, and will probably have go to the dentist to have some fillings."

Self-produced verbal consequences may well have reinforced rule-governed toothbrushing in the current experiments, but if so they were not directly trained, and they did not maintain toothbrushing in the Follow-ups at the highest levels seen during the intervention conditions. It is possible, however, that methods that focus more attention on shaping the ongoing covert verbalizations of the subjects may have been more successful. For example, Meichenbaum (1986) describes a self-control training procedure designed to teach children "to use task-relevant self-statements which identify the nature and demands of the task in order to generate an appropriate strategy; self-guiding self-statements and cognitive rehearsal to implement an appropriate strategy; self-monitoring; error correction and coping self-statements to evaluate progress; and self-reinforcing statements to acknowledge one's efforts. Such techniques as modeling, overt and covert rehearsal, fading and successive approximation are incorporated into the training regimen." (p.28). As mentioned in Chapter 2 (Section 2.1), however, such a procedure might be difficult to teach to parents.

6.6. PRACTICAL IMPLICATIONS

Several studies have shown that dental health promotion programmes often have little effect on the toothbrushing behaviour of children (see Gatherer, Parfit, Porter & Vessey, 1979; Locker, 1989). This has led some researchers to conclude that young children are unable to brush their teeth effectively.

> "It is generally agreed that most children are incapable of the motivation and manual dexterity required to achieve effective plaque removal with a toothbrush until at least 6-7 years of age." (Levine, 1986, p.17)

The current research indicates, on the contrary, that five and six year old children, given training based on behavioural principles can very greatly improve the frequency and quality of toothbrushing, and reduce dental plaque to very low levels. Two earlier studies (Blount, Baer & Stokes, 1987; Swain, Allard & Holborn, 1982) examined the effects on children's dental hygiene of implementing school-based contingency management programmes. Both demonstrated a considerable decrease in children's plaque levels, and these reductions were maintained for several months. However, in this and other previous research, toothbrushing behaviour was not monitored directly, that is, the factors responsible for the reduction in plaque levels were not assessed. The current research is a significant contribution to the study of dental health promotion since it provides, as no other study has done, a daily videotaped account for several months of the toothbrushing behaviour of twenty eight children aged five to six years old. Precise behavioural data have been collected concerning the effects of several interventions on children's frequency, durations and number of locations of toothbrushing.

The first experiment confirmed that changing a rule for behaviour may leave the behaviour itself unaffected; what is necessary is to establish a 'correspondence' between a rule given to children about their toothbrushing behaviour and what they actually do. This programme of research has developed procedures that promote such correspondence successfully. This research has established effective and reliable methods of measuring the durations and locations of children's toothbrushing behaviour. It has examined the use of disclosing agents, both as a method of promoting effective toothbrushing, and as an aid to the assessment of dental hygiene. It was shown that parents learned, with very little tuition, to conduct accurately a modified version of the *Plaque Control Record* to provide an index of dental hygiene, and that this measure appeared to reflect improvements in toothbrushing behaviour. Finally, this research has led to the development of a stimulus control device (the Toothtutor), which has been demonstrated to be an effective teaching aid when used in conjunction with the Compliance Training procedures. It was shown (in Experiment 4), however, that without the Compliance contingency the Toothtutor alone will not lead to lasting effective changes in behaviour.

Clearly, this research is exploratory and further research should be conducted to confirm the findings. The effects of the interventions on behaviour need to be confirmed with larger numbers of subjects, and the effects on dental hygiene need to be assessed by dental professionals to demonstrate unequivocally their clinical significance. Further research should assess more comprehensively the relationship between dental behaviour (frequency, duration and locations of toothbrushing) and dental hygiene to determine more precisely the optimal levels of behaviour. Indeed, at present, there are not even clear guide-lines concerning the relationship between plaque levels and incidence of dental caries and periodontal disease. Thus far, dentists have adopted the philosophy that less plaque is better, without a clear criterion as to how little plaque is good enough (Blount, Baer & Stokes, 1987).

Given this uncertainty, and the finding (if we accept the parents' scores) that children's hygiene levels remained consistently high, it may be that the behaviour change recorded at Follow-up, although lessened, was sufficient to maintain 'good' dental health. This being the case, the results of the current programme could lead eventually to the widespread distribution of a comprehensive behaviour change package, that could be used in families anywhere, to encourage children to brush their teeth effectively. The next step may be to take what is learned from this programme and, with additional research, package the essential components in the most 'cost-efficient' way, test the refined package with large groups of subjects, and if successful, disseminate the findings widely to the public.

The findings of this programme may have implications not only within the domain of dental care, but also a range of other behaviours in children. This research has examined how rules, contingencies, and environmental cues, can all be employed by parents to promote effective self-regulation. The behaviour change strategy, developed in the course of this research, could thus be modified and implemented to empower children to acquire self-control of a variety of activities, such as self-care, food choice, reading and study skills, physical exercise and sport. Work along these lines has already been initiated within this department, with considerable success, on children's food choice. Clearly, much remains to be done.

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