

Perspectives on the Status of Sensory Integration Theory

Linda Tickle-Degnen

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Sensory integration theory has generated many studies over the past decade, and individuals who are evaluating the theory and its ramifications for treatment have started to draw conclusions based upon those studies. However, the theory underlying treatment has not been fully explored through research, nor have the bulk of the treatment effectiveness studies demonstrated the methodological and statistical power necessary to adequately accept or reject effectiveness. The purpose of this article is to examine how research on sensory integration therapy relates to the underlying theory of therapy, how it is guided by the theory, and how it can be used to evaluate and develop the theory. The perspective taken in this discussion is that of a professional who does not have the experience of practicing sensory integration treatment but who is informed through the published research in the area. It is hoped that the resultant simplicity and objectivity of the discussion will provide a useful analysis of the complex issues surrounding research in this area. Suggestions are given for improving the knowledge of "outsiders" about the theory and practice of sensory integration treatment through research.

At the time this article was written, Linda Tickle-Degnen, PhD, OTR, was a doctoral candidate in social psychology at Harvard University. (Mailing address: 15 Mystic View Terrace, Arlington, Massachusetts 02174.)

I do not have any clinical experience in sensory integration therapy. As an occupational therapist, I have worked primarily in geriatrics and physical disabilities. Lack of advanced training and experience in sensory integration therapy could be disadvantageous to someone attempting to analyze sensory integration theory and research. On the other hand, the lack of knowledge is potentially advantageous because it allows me to have a perspective unencumbered by a complexity borne of experience and large amounts of information. In the discussion that follows, I have attempted to balance simplicity of perception with a systematic and logical analysis of the published empirical literature as related to theory underlying sensory integration therapy. In short, my perspective is that of an informed outsider.

My strategy is to systematically expose my knowledge—and my ignorance—by building simple, general models describing the effect that sensory integrative therapy has on the treated person. To build these models, I progressively examine the relationship between sensory integration theory underlying the therapy and the relevant research. My primary purpose is to delineate, by drawing upon basic research principles, how the theory and the research intermingle, how they work together, and how from one the other develops. I start with simple, concrete models and work towards more complex, difficult-to-operationalize models.

Observations about the state of current research and possible directions for future research are made during the discussion. By determining how to respond to my lack of knowledge and my general observations, practitioners of sensory integration therapy may determine, in part, how to respond to others "out there": the school teachers, the operant conditioners, the physicians, and the funders of special programs.

Overview of the Models of Analysis

Two models of sensory integration treatment effectiveness, labeled with terms used by Rosnow (1981), form the basis for the analysis of sensory integration theory and research. One is a *synchronic* model, a model of immediate response that describes what sensory integration therapy does during the moment of treatment delivery. The other is a *diachronic* model, a model of change that describes the effect of sensory integration over successive periods of time.

These two models can be used within the contexts of two levels of research. What I call *Model 1 research* tests whether or not sensory integration therapy is effective. *Model 2 research* is designed to determine how and why the therapy is effective.

Basic Effectiveness Research: Model 1

Synchronic Model 1

The simplest synchronic model is Model 1 (see Figure 1). Its elements consist of a known, objectively defined sensory input and an observable response. The model suggests the hypothesis that different types of sensory input result in different kinds of responses, and specifically, that "therapeutic" sensory input results in an adaptive response. A few research studies (e.g., Reilly, Nelson, & Bundy, 1983; Slavik, Kitsawa-Lowe, Danner, Green, & Ayres, 1984) have been done with this hypothesis in mind.

The feedback loops in the model, including a loop from the adaptive response into the therapist-controlled sensory input and another loop directly back into the child's own nervous system, do not appear to have been studied. Research into the feedback loops would require an examination of change occurring within the course of one treatment session. If the model were correct, one would expect the nature of the sensory activities to which the therapist was exposing the child to change as a result of the child's responses and thus affect the child's subsequent responses. Certain types of change in the therapist's control of the input may be more beneficial than other types of change from the feedback. Some therapists may be more responsive to the feedback than other therapists, thus affecting the child's adaptive responding, and so on.

The model also suggests that the adaptiveness and type of the child's response would affect subsequent responses through direct physiological feedback into the child's own nervous system. For example, one adaptive response of the child would possibly raise the probability of a second adaptive response.

Diachronic Model 1

The effect of therapy over multiple sessions is represented in the diachronic model (see Figure 2). This model is usually followed when pretest/posttest effectiveness research is performed (e.g., Ayres, 1972, 1978). After a period of therapy lasting several weeks

Figure 1
Synchronic Model 1 of Sensory Integration Therapy Effectiveness

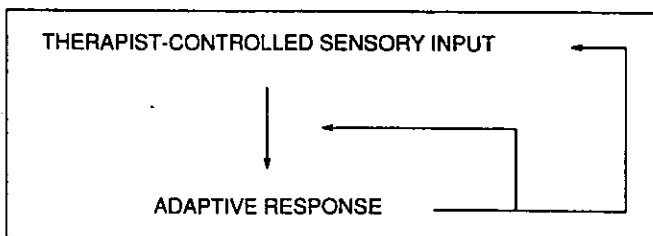
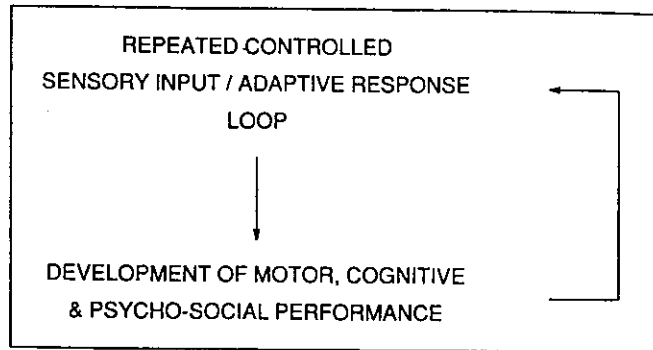


Figure 2
Diachronic Model 1 of Sensory Integration Therapy Effectiveness



to a year the child is evaluated for motor, academic, and social psychological progress.

The model has broader implications than the use of a simple pretest/posttest design. With the use of this model, multiple measurement periods occur in the course of therapy. The researcher follows the actual progression of the change rather than just determining how the child fares at the end of the overall therapy period. Single-subject research is particularly suited to a design of multiple baseline and multiple treatment measurement periods.

Research with the feedback loop in mind would be directed not only toward progression in the child, but also toward the type of sensory input opportunities and environment provided to the child by the therapist as this input is transformed by the development of the child. Many sensory integration case studies address this progressive development in input as it changes with the child's responses (e.g., Ayres & Mailloux, 1983). The model suggests that one could evaluate whether general rules underlying the therapeutic progression of sensory input were or were not valid. For example, would a progression of therapy from phylogenetically primitive sensory experiences towards less primitive experiences be more beneficial than another type of progression? Perhaps, however, the individualized nature of treatment would preclude such an investigation.

Another unexamined implication of the feedback loop in this diachronic model is that the child's own physiological feedback processes over the course of therapy may change, possibly by way of becoming more efficient or integrated in nature. Additionally, a concurrent change in adaptive responding would be expected to occur.

From the "If" to the "How" of Therapy Effectiveness

Building Upon Model 1 Research

The models discussed so far are based on a simple hypothesis: Sensory integrative therapy leads to good

things for a child. Obviously, the models do not begin to approach an explanation of all of the aspects of the theory of sensory integration underlying therapy. But, already it is becoming clear how the explication of simple theoretical links can guide research or aid in the categorization of research.

In clinical research examining the effectiveness of a particular type of new treatment, the beginning of that research will often stick to the kind of models just discussed. The elements, or variables, are relatively easy to operationalize. The sensory input can be carefully described and, to some degree, quantified, as can the performance of the child. The primary purpose of research at this stage is to determine *if* treatment is effective, not necessarily *how* it is effective.

At any stage of research, replication is important. The effectiveness of the therapy must be demonstrated repeatedly, with a variety of clinical researchers showing effectiveness. If only one researcher shows effectiveness while others do not, the effectiveness of the therapy may have something to do with the researcher rather than with the therapy. Moreover, if the findings are to be generalized to various types of patients, the research must be done with different samples of individuals.

As the research progresses, the model is revised in two general ways. First, researchers, by way of theoretical implications, clinical evidence, and the use of blocking factors in research designs (for example, by analyzing together and separately males and females or younger and older children), look for *moderating* factors that influence the effectiveness of therapy. Moderating factors are those qualities of the child, the therapist, and the environment that determine whether the therapy tends to be effective or ineffective.

Second, the model is revised by uncovering *mediating* factors that account for the effectiveness of the therapy. Mediating factors are all those processes and elements that come between the two end points in the simple models. They help to explain why and how therapy works. As will become apparent in the next section, the search for moderating and mediating factors may occur in a complementary and simultaneous manner. (See Rosenthal, 1981, for a discussion of moderating and mediating variables as they are investigated in relation to the study of interpersonal expectancy effects.)

The Search for Moderating Factors

In sensory integration research, much attention has been directed towards moderating factors as related to qualities of the patient. Age of the patient appears to be a crucial moderating factor. Past a certain age, therapy does not appear to be as beneficial as at earlier ages (Ayres & Mailloux, 1983). Such a finding not

only delineates the conditions under which the model is most accurate, but it also lends support to a mediating factor in the model related to plasticity of the brain, that is, the hypothesis that the therapy works through change occurring in the physiology and structure of the brain.

The fact that some research shows sensory integration treatment effectiveness with adults (Clark, Miller, Thomas, Kucherawy, & Azen, 1978) has three possible implications for the mediating factors associated with effectiveness. First, it is possible that the mediating factors that determine effectiveness in adults are different from those that account for effectiveness in children. Second, perhaps brain change is not the determinant of effectiveness in children or adults, rather, a different factor that is similar for both children and adults (e.g., individualized attention) is the determinant. Third, it is possible that plasticity of the brain is present in adults as well as children.

Other moderating factors associated with patients' characteristics are diagnosis and type of sensory-integrative dysfunction. Children with learning disabilities who show a particular type of sensory-integrative dysfunction appear to improve with sensory integration treatment to a greater degree than children who do not show this type of dysfunction (Ayres, 1978). Degree of responsiveness to various types of stimulation has been found to be another moderating factor in patients (Ayres, 1978; Ayres & Tickle, 1980).

Relatively unexplored but potentially significant moderating factors related to the general treatment situation are length and frequency of treatment. These factors could be examined in a meta-analysis of the existing literature (Rosenthal, 1984), that is, a quantitative summary of the existing empirical studies on the effectiveness of treatment programs of differing lengths or frequencies.

Other unexplored factors are the therapist's qualities and other environmental moderators. Studies have not been performed to examine the effect of the therapist's qualities, such as sex, training, personality, or expectations for the child, on treatment results. Although these factors may not be crucial for evaluating the theory of sensory integration therapy, they certainly would have important clinical ramifications.

Throughout the discussion of moderating variables, I have not changed the models presented because what the moderators do primarily is narrow the applicability of the model. They determine the degree to which the therapy's effectiveness can be generalized to different therapists, patients, and treatment settings. The examination of moderators may also reveal that more than one model is needed for different subgroups. For example, there may be different models for children who are hyperactive and for children who have learning disabilities.

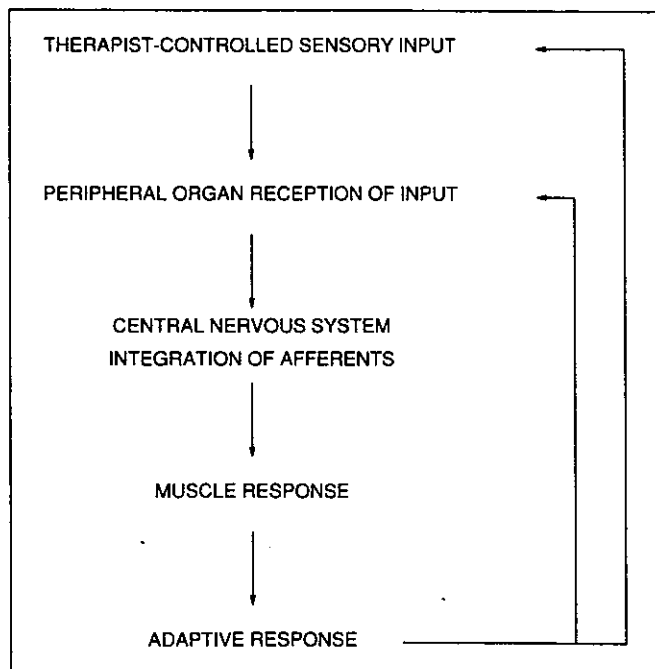
The Mediation of Effectiveness: Model 2

To answer *how* sensory integration therapy is effective, new and more complex models that incorporate mediation effects are needed. There are two types of mediating factors: those that can be observed and those that cannot. Inferences can be made about the nonobservable factors on the basis of what can be observed about the directly observable factors that are linked to those nonobservables in the model (Cronbach & Meehl, 1955). Three qualities that promote correct inferences about the nonobservable elements of the model are (a) clear delineation of the elements and relationships in the model, (b) high validity and reliability of measurement tools, and (c) direct links between nonobservable and observable factors. Through research of the various links in the theoretical model the model can be supported or fail to be supported; in the latter case, the model would need to be revised to reflect reality better.

Synchronic Model 2

Synchronic Model 2 (see Figure 3) shows what happens, theoretically, between the input of controlled sensory stimulation and the adaptive response output during one treatment session. This model has many observable variables that are not typically studied by occupational therapists. Research into this model requires the monitoring of neurophysiological processes during or directly after controlled sensory input.

Figure 3
Synchronic Model 2 of Sensory Integration Therapy Effectiveness



An investigation of the first link in the model would help to determine if input is being peripherally received as expected in the population being researched. For example, some research (Kantner, Clark, Allen, & Chase, 1976) suggests that vestibular stimulation occurs only when linear and vertical accelerations are of a particular magnitude and duration; therefore, not all linear and vertical accelerations would create a vestibular organ response.

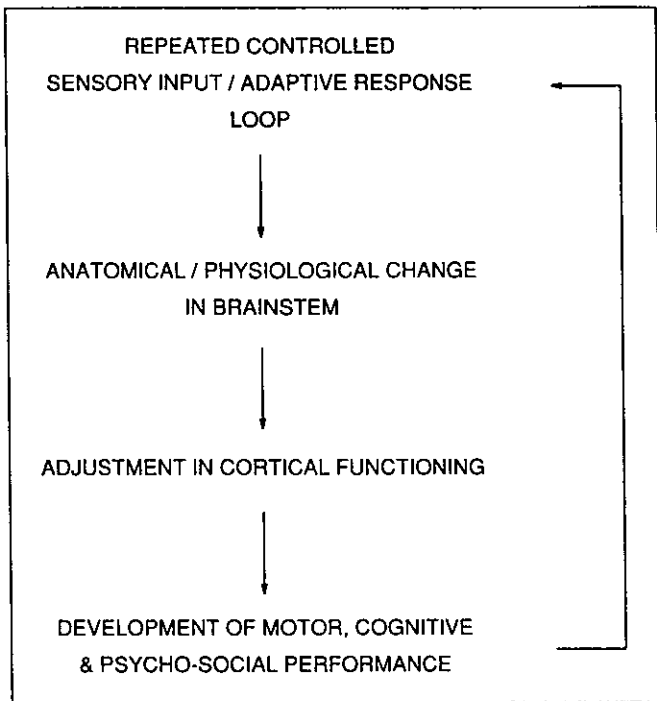
In the middle of the model is just one construct, "Central Nervous System Integration of Afferents." A more sophisticated model would have many links and elements in place of this one construct, such as a schematic diagram of impulses coming into the brain and passing through some central connecting stations at the brain stem level, the thalamus region, a cortical receiving area, and finally through some areas for processing and interconnections with motor neurons. Although this whole process is largely nonobservable through current technology, a little of it can be observed through tools such as positron emission tomography (PET) scans. It is possible to visually monitor the brain of persons in different types of activity by watching where the glucose in the brain is being metabolized at the greatest rate or where blood flow is greatest (Mazziotta, Phelps, Carson, & Kuhl, 1982). Electrical monitoring of the brain is probably the more practical research method available to occupational therapists in rehabilitation settings. An example of the use of the electroencephalogram (EEG) can be found in a study by Kantner, Clark, Atkinson, and Paulson (1982) of the effect of vestibular stimulation on the electrical activity of the brains of seizure-prone children.

Other relationships in this model could be examined, such as those involving the factor labeled "Muscle response." The electromyogram (EMG) could be used to measure subtle changes in the motor responses to different types of input, or as they relate to brain activity. The feedback loops could be addressed in the same way as in the Model 1 synchronic model.

Diachronic Model 2

Diachronic Model 2 (see Figure 4) is a very general model showing what is proposed to occur over many treatment sessions with therapy. The model contains a couple of potentially controversial components. The idea that the brain anatomy or physiology is actually changing or developing as a result of the controlled sensory input/adaptive response cycle is one of these components. Since brain change, as far as I know, is a nonobservable factor in living organisms, it is difficult to establish support for its role in the mediation of the effects of sensory integration therapy. Brain change can be inferred only from indirect observable variables, such as change in a child's performance.

Figure 4
Diachronic Model 2 of Sensory Integration Therapy Effectiveness



There is, however, some support for the long-term effect of elements of sensory integration therapy on change in the central nervous system. For example, research suggests that postrotary nystagmus may change with controlled sensory input over time (Kantner et al., 1976; Ottenbacher, 1982a) and that hemispheric specialization may be affected by sensory integration therapy (Kawar, 1973).

Another potentially controversial link in this model is the idea that change at the brain stem level will affect cortical functioning in such a way as to affect academic achievement or language. It is easier to understand how different forms of sensory stimulation might influence motor performance (through reflex arcs, etc.) than it is to understand how stimulation of a noncortical nature might influence language and academic achievement.

This proposed relationship is probably the most controversial in the theory underlying sensory integration therapy, not only because of the indirect correspondence between the stimulus and the predicted performance variable, but also because it has powerful implications for how the brain functions. One implication is that portions of the brain that are more phylogenetically primitive must be functioning adequately for the less primitive portions to be functioning optimally. I am not aware of research performed to determine causality of change in brain functioning: Does sensory integration therapy work to produce its influences primarily at the brain stem level or at other

levels? Or does it cause a whole-brain response, in which case these questions of causality are not appropriate?

It is very difficult to substantiate some aspects of the links in this model because they are highly theoretical and difficult to observe. However, it is not appropriate to conclude on the basis of this difficulty that the theory is not correct. Not enough results are in to arrive at a conclusion.

The Status of Sensory Integration Theory

The status of sensory integration theory is defined to a great extent by the status of the research. Therefore, because occupational therapists are concentrating their research efforts at the Model 1 stage and are not conducting much research on mediation factors at the Model 2 stage, the theory being tested and receiving some support is a simpler one than the full model of sensory integration theory.

Concentration of research effort at the Model 1 level is typical when a new treatment is being evaluated. Why examine mediation factors before it is known if, and under what conditions, treatment is effective? The field of psychotherapy, for example, began controlled effectiveness research during the 1950s, and much of this research was surrounded by a considerable degree of controversy. A ground-breaking meta-analysis by Smith, Glass, and Miller (1980) of 475 controlled studies demonstrated that psychotherapy indeed was effective as demonstrated by a comparison of experimental and control groups.

In occupational therapy, Ottenbacher (1982b) performed a meta-analysis of sensory integration effectiveness studies. Although he found a substantial positive effect of therapy, the number of studies he found in 1982 that met his criteria for inclusion (the research study had to have a control group for example) was only eight. Clark and Pierce (1986), in a qualitative literature review, found thirteen studies with sensory integration procedures as the independent variable, four that examined systematically applied vestibular stimulation, four of multisensory input, and five of perceptual motor training. Occupational therapy research in this area is just beginning.

The Need for Power in Research

At this early stage of research in this area, it is extremely important to build power into the investigations—power that detects effectiveness if it truly exists. If studies have low power, they may fail to show that sensory integration therapy is effective, an outcome that would be tragic for patients who could benefit from the therapy but would not be able to receive it because treatment funding would be lost.

One can increase statistical power through the

use of large sample sizes. The larger the sample size the more likely the researcher is to find effects that are significant if the effect truly exists. Because of the hypothesized long-term and cumulative effects of sensory integration therapy, it is not easy to build statistical power into single-subject research (for example, by randomly administering a large number of treatment and control conditions to a single subject and then using the multiple observations as sampling units in a statistical analysis). However, statistical power with small sample size studies, of about four patients, can be achieved by having several therapists do studies and then combining their results using meta-analytic techniques (R. Rosenthal, Professor, Department of Psychology, Harvard University, personal communication, January 1987; also Rosenthal, 1984).

Careful choosing of treatment and control subjects is another way to be sure that effectiveness will be demonstrated if sensory integration therapy is truly effective. Ayres (1972, 1978), for example, carefully chose subjects for her studies that fell within the groups who could profit from sensory integration therapy, or designed the study so that it would discriminate between those who did and those who did not. She matched her subjects who were to receive treatment with control, no-treatment, subjects on several variables, such as age, type of dysfunction, and IQ. Using this type of care in the design of studies prevents uncontrolled variables from masking the effectiveness of therapy for certain groups of patients and from creating a situation in which it could be argued that factors other than the therapy itself account for patients' gains.

Through many replications of studies by various investigators, the use of carefully planned control conditions, and the evaluation of moderators, a picture will emerge regarding the effectiveness of sensory integration: whether or not sensory integration treatment is more effective than no treatment, than other types of less costly treatments (including special education classes), than a therapist's positive expectations for the child, than individualized attention, or than fun and novel situations. No single study can determine whether the treatment is effective or ineffective. Cooper (1984) makes a point that can be applied to research of therapy effectiveness:

The value of any single study is derived as much from how it fits with and expands on previous work as from the study's intrinsic properties. Although it is true that some studies receive more attention than others, this is typically [*sic*] because the piece of the puzzle they solve (or the puzzle they introduce) is extremely important, not because they are solutions in and of themselves. (p. 9)

The discovery of knowledge is a cumulative process

in which investigators build upon the results of past research. Theory provides the guidelines for how the research is to be conducted in order to solve the puzzle, and as each part of the puzzle is solved, the theory is revised to better accommodate new information.

Occupational Therapists and Mediation Research

The model involving mediating factors in sensory integrative therapy effectiveness has not yet been explored in great detail by occupational therapists. Traditionally, basic science knowledge of the Model 2 type has been gleaned from the research of neuroscientists. A practical solution for occupational therapy involvement in mediation research investigating sensory integration therapy issues would be to have the occupational therapist, who knows what questions are the most relevant ones to be researched, coordinate the involvement of various disciplines in carrying out measurements that are more germane to the expertise of these disciplines (e.g., EEGs, PET scans, etc.).

It might be premature to jump into this type of research because it would take occupational therapy resources from the much needed research of Model 1. On the other hand, there will probably be a great deal of pressure from persons outside of occupational therapy for basic science (Model 2) types of research to support the theoretical and controversial claims of sensory integrative therapy. People, in general, are less likely to be convinced by theory than by empirical evidence.

Conclusion

The models described in this paper were used not to serve as the best representation of current sensory integration theory but as a basis for a discussion of the relationship between theory and research in this area. It is the models of qualified sensory integration theorists that should be used for the purpose of guiding research. In addition, it is the task of theorists and clinicians to determine which links in their theoretical models require priority in terms of research and then to coordinate research efforts to ensure that studies address high priority links and build on one another in a systematic way.

There is a considerable difference in the quantity and type of knowledge that an occupational therapist who practices sensory integration therapy carries and the knowledge that others carry about sensory integration therapy. The best way to remedy the ignorance of others is by using research not only as a tool of theory but also as a tool of communication and by publishing in interdisciplinary as well as occupational therapy journals.

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