

On the historical and conceptual background of the Wisconsin Card Sorting Test

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Abstract

In this paper, we describe the development of the Wisconsin Card Sorting Test (WCST). We trace the history of sorting tasks from the studies of Narziss Ach on the psychology of thinking, via the work of Kurt Goldstein and Adhémar Gelb on brain lesioned patients around 1920 and subsequent developments, up to the actual design of the WCST by Harry Harlow, David Grant, and their student Esther Berg. The WCST thus seems to originate from the psychology of thinking ('Denkpsychologie'), but the test, as it is used in clinical neuropsychological practice, was designed by experimenters working within the behaviorist tradition. We also note recent developments suggesting that, contrary to the general impression, implicit learning may play a role in WCST-like discrimination learning tasks.

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1. Introduction

The concept of executive functions has become very popular over the last two decades in clinical (neurological and psychiatric patients) and fundamental (neuroimaging) studies on the (pre-)frontal cortex (e.g., [Stuss & Knight, 2002](#)). These executive functions are assumed to serve as cognitive control processes, in particular for planning and organizing behavior. [Luria \(1966\)](#) argued that planning and organization of behavior occur in the prefrontal cortex. Clinical neuropsychological evidence seems to support this conclusion. For example, patients with frontal lesions due to traumatic brain injury show symptoms that are referred to as the Dysexecutive Syndrome ([Baddeley & Wilson, 1988](#)). Impairments in these executive functions are often assessed with the Wisconsin Card Sorting Test (WCST), along with a range of other instruments. According to [Lezak \(2004\)](#), the WCST is generally used

to measure the capacity to deduce concepts and to apply a strategy to adapt behavior to changing conditions. Over the years several variants of the WCST have been developed. In the original version of [Berg \(1948\)](#), switching of the relevant concept (generally referred to as shifting) occurred without a warning by the examiner, whereas this shifting was explicitly announced in the version of [Nelson \(1976\)](#). [Heaton, Curtiss, and Tuttle \(1993\)](#) have introduced a computerized version of the test. A test frequently used in research is the set-shifting subtest of the CANTAB ([Fray, Robbins, & Sahakian, 1996](#)).

In this paper, we trace the history of the Wisconsin Card Sorting Test (WCST) and similar sorting tasks, beginning with the studies of Narziss Ach on the psychology of thinking, via the work of Kurt Goldstein and Adhémar Gelb around 1920 and subsequent developments, up to the actual design of the WCST by Harry Harlow, David Grant, and their student Esther Berg at the Wisconsin University. What we find interesting is the apparent discontinuity, where the cognitive underpinnings of the task are quickly turned into a Behaviorist framework, and how long it has taken to rediscover its conceptual origins.

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2. Ach and the ‘Denkpsychologie’

Wilhelm Wundt (1832–1920) was the founder of psychology as an institution (Bringmann & Tweney, 1980). He first defined scientific psychology in his *Grundzüge der Physiologischen Psychologie* (*Principles of Physiological Psychology*; Wundt, 1873). Although in the 1870s the word ‘physiological’ was acquiring its current meaning, it was often used in a broader meaning, more or less indicating an experimental approach to the study of natural phenomena (Leahey, 2001). Wundt distinguished the experimental approach, using instruments to measure sensations and experiences (‘experimentelle Selbstbeobachtung’), from the more traditional way of examining mental processes purely introspectively (‘reine Selbstbeobachtung’). He argued that experimental psychology should focus on perception. In his view, thinking could not be analyzed with experimental procedures (Humphrey, 1951).

One of Wundt’s most outstanding students was Oswald Külpe (1862–1915). He wrote his dissertation under Wundt: ‘On the theory of sensual feeling’ in 1887 (Ogden, 1951). He became an assistant at Wundt’s Institute of Psychology in Leipzig, and subsequently was named Professor of Philosophy and Aesthetics in Würzburg (1894). Külpe strove to make psychology a more complete natural science and less a branch of philosophy: ‘...it would seem well to dispense with the idea of a general philosophy of mind, or of the mental sciences, altogether’ (Külpe, 1895, p. 64). Arriving in Würzburg, he immediately started a research program on thinking and in 1896 he founded, together with Karl Marbe (1869–1953) the Institute for Psychology. The development and formation of concepts was an important area of research within the Würzburg School (Hoffmann, Stock, & Deutsch, 1996). Abstraction experiments were used to establish which object features are relevant to individuals at various stages of their development. For instance, when will a child call an animal a dog?

For the investigation of thinking, Külpe developed the so-called *Ausfragen* (Questioning) method. The experimenter asked a question to an observer (usually a trained fellow researcher), for example, to produce an association to a given word. Afterwards, the observer had to describe the processes that occurred between the question and the answer; in other words, he was to describe his thought processes. The primary conclusion from this research program was that thinking can occur without images. Another important claim was the rejection of associationism as the fundamental mechanism for thinking. One of the arguments was the following: In response to the question ‘Give the superordinate category for bird’ a subject will say ‘Animal’, rather than ‘Canary’ which might be produced in a free association situation. It was hard to see how this behavior could be explained along associationistic lines. The students of the Würzburg School argued that the task itself, rather than the stimulus, directs the thinking process and thus activates the concepts that come to mind. They referred to this mechanism as *mental set* (Humphrey, 1951).

Narziss Ach (1871–1946) was a student of Külpe (Hoffmann et al., 1996). From 1898 until 1899 he studied psychology in Strassbourg and then returned to Würzburg to study under Külpe and to write a dissertation on the psychology of the Will. He began his experiments on the Will in the summer of 1900, working with Külpe, and continued these in Göttingen, while working with Müller. An overview of these studies can be found in Ach (1921). Ach designed a paradigm for observing the process of concept *formation* by the experimenter (rather than through introspection by ‘the observer’). Individuals were presented with cardboard (or wooden) geometrical figures, large or small in size, light or heavy in weight. To each object a small card was attached on which was written a meaningless word, for example, *Garun*, *Ras*, *Tal*, *Tar*, *Garun*, for instance, represented heavy objects. These words were read out loud by the experimenter and the cards were removed from the objects. Subsequently, the subject had to discover how the words were related to particular features of the objects. The meaningless words thus came to refer to a group of objects characterized by a common feature. This paradigm can be considered the model task from which other sorting tasks, including the WCST is derived. A basic feature of these tasks is that multidimensional stimuli are presented and the subject has to discover the sorting principle.

3. From Ach to Goldstein

A second phase in the historical background of the WCST is formed by the studies on brain lesioned patients of the German neurologist Kurt Goldstein (1878–1965). Much has been written about Goldstein and we will not attempt to give a complete picture of his life and works here; we refer the reader to sources like Goldstein (1967), Shakow (1966), and Simmel (1968). In this section, we will examine some factors that may reveal why and how he came to study this issue. We will focus on the period leading to the crucial publication of Gelb and Goldstein on patient Th. in 1920.

Goldstein studied medicine in Breslau, having a special interest in psychiatry, and he was taught by Carl Wernicke. He received his M.D. in 1903 and that same year he finished his dissertation on eye movements in schizophrenics. In 1904 he joined the *Senkenbergische Neurologische Institut* in Frankfurt-am-Main as assistant to Ludwig Edinger. In 1906 he became a staff member of the Psychiatric Clinic of the University of Königsberg. It should be noted that Ach became Professor in Königsberg in 1907 and worked there until 1922. In 1914 he returned to Frankfurt as first assistant to Edinger. With Adhémar Gelb he founded in 1916 a research institute for brain-injured soldiers, the *Institut zur Erforschung der Folgeerscheinungen von Hirnverletzungen*. His collaboration with Gelb was fruitful and resulted, among other things, in a book, *The Psychologische Analyse hirnpathologischer Fälle* (1920), which contains 16 studies, mostly dealing with perceptual problems.

Among them is the study on Th., in which sorting tasks were used and the notions of concrete and abstract attitude were developed.

The question we want to address is: How is the work of Goldstein related to the line of research on thinking psychology in general and the work of Ach in particular. Goldstein and the American psychologist Martin Scheerer (1941) wrote:

The problem (of impairments in abstract behavior in brain-injured patients, P. Eling et al.) was first discovered and experimentally attacked by Gelb and Goldstein, who, during and after the World War, introduced a number of methods for determining the capacity status of patients suffering from brain injuries. These authors and their collaborators devised special sorting tests, e.g., color and object sorting tests for that purpose (p. 1).

In this chapter, Goldstein indicated that, in his work in Frankfurt, the emphasis was on working with patients rather than on experimental research in the laboratory designed to address theoretical questions. A considerable part of his research was directed towards the problem of helping patients to find a new organization for their lives. The activities of the normal and pathological organism can be understood only if looked upon as determined by the basic trend to realize itself in the world as completely as possible under the given conditions. To understand the behavior of a patient, one should not focus on a specific deficit, but study all aspects and try to understand how they work simultaneously. Interestingly, Goldstein continues by arguing that ‘the holistic approach did not originate from any idea’ (p. 157). He then indicates that the ideas of internists like Kraus, Krehl, and Christian were relevant in this respect, and even more so Ludwig Binswanger. Furthermore, the English neurologist Hughlings-Jackson’s views also were relevant, but not generally known until Head wrote about them. Goldstein felt comforted by some ideas of the French physician Claude Bernard (1913–1878), for instance his statement that ‘in the organism... we have to consider an ensemble, a harmony of phenomena’, and ‘one should always return to the ensemble [of phenomena] before one draws definite conclusions’ (p. 158). Apparently, Goldstein considered this to be the background of his conception of the concrete and abstract attitude.

It is remarkable that Goldstein did not mention the work of Narziss Ach. In the period of 1907 until 1914 they were both in Königsberg, so it is plausible that they met there. Indeed, according to one short biography it was in Königsberg that Goldstein ‘became acquainted with the Würzburg School of experimental psychology, which emphasizes “imageless thought”’ (Anonymous).

Later, on learning about the work of the philosopher Edmund Husserl, Goldstein wrote that he felt ‘vaguely that my interpretation of the behavior of patients may prove to be similar to the results of the “phenomenological analysis”’ (p. 162). And his friend Gurwitsch (1949) claimed that

indeed Husserl’s views had been corroborated by Goldstein and Gelb’s studies of brain-injured patients.

4. Adhémar Gelb

Trying to find the link between the work of Narziss Ach and Goldstein, one might also suspect that the ideas were transferred via Adhémar Gelb (1887–1936). The Russian Gelb studied Philosophy and worked as a voluntary assistant at the Psychological Institute in Berlin, working under supervision of Carl Stumpf, with Max Wertheimer and Kurt Koffka. After finishing his dissertation there in 1910, he became an assistant at the Psychological Institute in Frankfurt am Main in 1912. During WW I a long and fruitful collaboration started with Goldstein in his institute for soldiers with traumatic brain injuries.

It appears then there were close personal ties between Goldstein and Gelb on the one hand, and some important Gestalt psychologists on the other. However, Ach also had connections with some of the pioneers of Gestalt psychology. According to Mandler and Mandler (1964), there is a line of development that stretches from the Würzburgers to Gestalt psychology. They also argue that Gestalt psychology did not become concerned with problems of thinking until 1920.

Returning to the question of the link between the work of Goldstein and Gelb and the thinking psychology of Ach, it seems that we cannot unequivocally demonstrate when, where, or how either Goldstein or Gelb were informed about the experimental approaches to the study of concept formation or abstraction. Although there are conceptual relations between the Würzburg School and the Gestalt psychologists, it seems likely that Goldstein and Gelb borrowed the sorting task as a paradigm for the investigation of concept formation or abstraction from the Würzburg tradition, in particular from Ach.

5. Goldstein and the abstract attitude

Gelb and Goldstein (1920) originally used a sorting task in the examination of a patient Th. who suffered from color amnesia. This was the Holmgren-test, a test for color blindness (see below for a more detailed description). Goldstein noticed that neurological and psychiatric patients performed it in a way that differed remarkably from that of healthy persons. He also saw that patients tended to look at individual objects; they apparently cannot avoid the concrete object and detect similarities between objects with respect to a particular feature. These observations led to the notions of *concrete* and *abstract attitude*, for which Goldstein became so famous. Healthy individuals have the abstract attitude, enabling them to abstract features, choose concepts with which the environment can be structured and organized. Brain-damaged patients are limited to the concrete attitude and, therefore, are dependent on external stimuli, which can lead to rigidity or a lack of abstract attitude as a fundamental way of dealing with

the environment, determining perception as well as thinking and action. Especially for that reason, one cannot assess attitude with a simple test and summarize performance with a simple test score.

6. Sorting tasks

In this section, we will focus on the various sorting tasks that have been developed and used, in particular for the study of brain-injured individuals and patients with schizophrenia. Here, we will mainly concentrate on procedural aspects, first of some tasks used by Goldstein and followers, and then the Wisconsin Card Sorting Test and the Halstead's Category Test. Subsequently we will discuss how performance on these tests were interpreted.

To analyze disorders in abstract behavior, Goldstein specifically used sorting tasks. Goldstein and Scheerer (1941) provided an analytical description of a number of these tasks. The first variant, the Gelb–Goldstein color sorting test, was derived from the Holmgren test. It was designed by Gelb and Goldstein in 1924 to examine their patient Th. In a first condition, the patient was asked to select one from a series of colored strings and subsequently to select those strings that were similar to the first one. In a second condition three strings were presented; the left and middle string matched in color, the right and middle string matched in brightness. The patient had to indicate which string matched the middle one. In a third condition, two rows of six strings were presented, one row varying from light to dark red and a second row with strings varying in color, but all with the same clarity. The subject had to select the strings that matched to each other. In a fourth condition, the subject had to formulate the reasoning underlying his responses. There was no quantitative scoring procedure because Goldstein was convinced that the specific attitude could not be expressed in a single test score; the experimenter had to observe how the subject performed the tasks.

Egon Weigl (1901–1979) developed a variant, the Gelb–Goldstein–Weigl–Scheerer Sorting Test. He used it in his study, performed at Goldstein's institute in Frankfurt in 1927, on a patient with frontal brain damage (Weigl, 1942). The test consisted of a set of common objects, used in daily life activities, which the patient had to sort in different groups, for instance, according to color, material, or usage. He subsequently had to sort them according to a new criterion and, therefore, had to shift. In the Weigl–Goldstein–Scheerer–Color Form Sorting Test the patient had to sort geometrical objects (triangles, squares, and circles in the colors red, green, yellow, and blue) according to color or form.

The Russian psychologist Lev Vygotsky (1896–1934) was also interested in concept formation, especially in children, but also in schizophrenic patients. He published a short note on sorting behavior in these patients in 1932 (see Hanfmann, 1968). His test consisted of 22 wooden blocks in five different colors, six forms, two heights and two sizes of the ground surface. Four cards with a nonsense

word were located in the four corners of a large board (*lag, bik, ruur, cev*). The subject was told that the set of objects consisted of four types of blocks, each with its own name, and that he had to discover which block belonged to which name. Hanfmann and Kasanin (1937) introduced Vygotsky's test in the United States in their research on schizophrenic patients (see also Hanfmann, 1968).

7. Wisconsin Card Sorting Task

We have followed the development of the psychological investigation of thinking and the introduction of sorting tasks. We have seen how Goldstein and Gelb, followed by others, applied the task in their studies on patients. After emigrating to the United States, Goldstein also introduced this task in his clinical work (for instance, see Bolles & Goldstein, 1938). We now will discuss the development of the Wisconsin Card Sorting Test.

In 1946, Myra Zable and the American psychologist Harry Harlow (1905–1981; Suomi & Leroy, 1982) examined discrimination learning of object features in rhesus monkeys, with and without brain lesion, in the primate center of the University of Wisconsin. They also studied whether these animals could learn another discrimination after having mastered a first rule, the shifting procedure. In their studies, they developed a paradigm for collecting quantitative data. Harlow later became known for his studies on the effect of terrycloth mothers on the development of infant monkeys, a research program on love or affection. Originally, he had been trained in Stanford as an experimental psychologist and after finishing his dissertation, he moved to the University of Wisconsin where he founded the Psychology Primate Center in 1930. The financial aspects at his primates center there caused him some concern and he asked his colleague, David Grant, professor of Psychology at the University of Wisconsin, whether they could collaborate (Hake, 1979). Together they formulated a research project for designing a paradigm, similar to the one used in the primate studies, in order to investigate human subjects. Esther Berg, a psychology graduate student, was given the opportunity in 1945 to write her masters thesis on this project under supervision of Grant. The thesis was approved by Grant in January 1946.

The main question in this project was, Can some method be found that will lend itself to both quantitative and qualitative analyses? The materials consisted of a set of 60 response cards with, on each card, one to four identical patterns (stars, crosses, triangles, and circles) all in the same color (red, yellow, green, or blue). The participant was requested to put each card under one of four stimulus cards and to deduce the sorting principle on the basis of feedback (correct, incorrect). Responses were scored in terms of errors, latency, and degree of perseveration and, according to Berg, provided a reliable and objective measure of the capacity to shift.

The thesis, with minor adaptations, was submitted and accepted for publication in the *Journal of Experimental*

Psychology in 1948, followed quickly by a study by Grant and Berg (1948), in which already the name “University of Wisconsin Card Sorting Test” was used. The materials and procedures of Berg’s study formed the basis of the WCST as it has been used by clinical neuropsychologists, starting with Milner in 1963 (see below).

8. Category Test

Another sorting test may be mentioned here, namely the Category Test from Halstead, a subtest of the Halstead–Reitan test battery (Choca et al., 1997; Reitan, 1994; see also Parsons, 1986). Ward Halstead (1908–1969) developed the test with Paul Settlage in 1943, who was working in Harlow’s primate center (Choca, Laatsch, Wetzel, & Agresti, 1997). Already early in his career (around 1935), Halstead examined patients with brain lesions at the Medical School at the University of Chicago. Originally he used an object sorting test, resembling the test of Goldstein and Scheerer. However, he wanted to have an objective score and decided to design a new version. The original version of his Category Test had 360 geometrical pictures grouped in nine subtests. After each subtest the relevant sorting rule changed. For each picture the subject had to indicate to which group it belonged by pressing one of four buttons. Many variants of this Category Test have been developed and they appear to be equivalent (Choca et al., 1997).

9. Wisconsin Card Sorting Test: abstracting, reasoning, or discrimination learning?

We have seen how the WCST was developed as a kind of sorting task, originally introduced within the tradition of the ‘Denkpsychologie’. We will now discuss what the performance of individuals on these kinds of tasks was assumed or claimed to reflect. According to Goldstein (Goldstein & Scheerer, 1941), sorting tasks mainly are designed to assess conceptual thinking, and he emphasized that the test primarily evaluates the categorial or abstract attitude. The abstract attitude implies that a person should be able to abstract from the concrete object to note similarities between objects with respect to a particular feature. According to Goldstein, the person also must have insight in the potential choices. The classification principle is unknown and the subject’s task is to discover this rule by trying various possibilities. This applies to discovering a sorting rule, but also to finding a *new* rule when an old rule no longer seems to apply, that is, after a ‘shift’. The value of the test, according to Goldstein, lies in the qualitative analysis of the subject’s approach in this task. He argues also that the quantitative scoring procedure used in other mental tests (e.g., subtests of an intelligence scale) is not useful for these sorting tasks, not because a procedure for calculating a score had not yet been developed, but because the nature of the thinking disorder cannot be expressed in a number.

Berg (1946) showed that, using the WCST procedure, both learning a rule and shifting to a new rule can be mea-

sured simply and adequately. She referred to this capacity as *flexibility* in thinking. In the discussion section of her report, she addressed the question of what is exactly measured and her answer simply was “the interpretation of these scores depends on further experimentation”. Grant and Berg (1948) referred with a single sentence to the tests of Goldstein and his co-workers as ‘tests for *abstract reasoning*’, but immediately discussed the task in terms, familiar to the behaviorist tradition, as studies on the effect of reward (feedback for a correct response) during learning. In the discussion section, they argued that this feedback perhaps can be seen as a reward that enhances the abstract attitude, but one can also look at it as a kind of stimulus–response learning. In their later papers, Grant and his co-workers focused on whether discovering the number rule is easier than the color, or whether the configuration of the elements on the cards (regular vs. random pattern) influences discrimination learning. In these papers one no longer finds any comments or speculation about the underlying psychological functions or mechanisms.

Some less orthodox adherents of the learning theory approach, like Tolman and Krechevski, did attempt to show in the 1940s that there had to be mediators, represented somehow in the brain (Tolman, 1966). For instance, Krechevsky (1932) referred to hypothesis learning; he assumed that in a discrimination learning task an organism uses a sort of hypothesis, that is, an idea about the rule relating a stimulus to a reward. However, this approach was not very popular in behaviorist circles, and Grant does not refer to this literature. We therefore conclude that for Grant the WCST was an instrument to investigate discrimination learning within the behaviorist tradition.

10. WCST as a neuropsychological test

We will now briefly describe the final phase of the WCST, in which it was introduced as a neuropsychological instrument, first for the evaluation of frontal lobe lesions, and later for the assessment of the so-called executive functions. Harlow, Grant, and Berg developed a discrimination paradigm that could be applied in human studies. Despite the fact that Goldstein and others had used sorting tasks in patient studies, it took some 15 years before the WCST was introduced as a test to study patients with brain lesions. In 1963, the psychologist Brenda Milner used the WCST in her well known study *Effects of different brain lesions on card sorting: the role of the frontal lobes*. In the introduction section of the paper she referred to sorting tasks. She mentioned Goldstein and Weigl, but did not discuss the notion of abstract attitude or any other cognitive processes. The data showed that in particular lesions in the dorsolateral part of the frontal lobe result in problems with shifting to a new sorting rule. Milner interpreted this as *perseveration*. In an attempt to specify the nature of the disorder she argued that frontal lobe lesions result in a loss of response inhibition. Like Grant, Milner seemed to prefer to describe behavior on this test in S–R-terms.

In the last quarter of the 20th century, interest in the study of the effects of frontal lesions has increased tremendously (see for recent overviews, Miller & Cummings, 2007; Stuss & Knight, 2002). The reason was not that the frontal lobes were terra incognita (although that was true to some extent in comparison to other cortical areas), but that investigators realized that it played a crucial role in the control of behavior, planning and organization as Luria (1966) had demonstrated. The British psychologists Baddeley and Hitch (1974) introduced the notion of Central Executive and the British psychologist Shallice (1988) that of Supervisory Attentional System. According to Baddeley (1986), the two concepts overlap considerably. This system is generally regarded to be involved in controlled rather than automatic cognitive processing and, hence, may well be related to conscious processing, or even consciousness. Research on cognitive disorders often addresses aspects of controlled behavior, and, therefore, it is not surprising that the study of executive functions in almost every kind of neurological and psychiatric syndrome has become so popular. Nearly always the WCST is used, together with other tests, as an instrument to study executive functioning. Perhaps one can say that the WCST is now the golden standard for disorders of the frontal lobe or in executive functioning.

More recently, however, some studies have shown that the WCST has some limitations. One may question to what extent the WCST adequately assesses frontal lobe functioning and executive functioning. Modern imaging studies have shown that the frontal lobes are, functionally seen, heterogeneous, suggesting that the WCST, at best, can only reveal specific aspects of frontal lobe processing (see chapters in Miller & Cummings, 2007). Also, the notion of Executive Functioning refers to a rather complex set of processes that appears to be necessary for nonautomatic behavior. Andres (2003) indicates it is time to revise our views on the functional role of the frontal lobes. The WCST, at best, may only tap specific aspects, in particular the shift from using an old rule to a new rule. However, the issue becomes even more complicated, when looking at studies examining mechanisms involved in shifting. For instance, Owen et al. (1993) have demonstrated that perseveration is not the major factor causing errors, but learned irrelevance is. Learned irrelevance refers to the phenomenon that a feature, which a subject has learned is irrelevant in a specific discrimination task, takes longer to become detected as the relevant feature after a shift. Traditionally, perseveration has been regarded as the significant indicator for impaired executive functioning. However, in the WCST it is not possible to dissociate between these two potential sources of errors. Maes, Damen, and Eling (2004), Maes, Vich, and Eling (2006) have replicated this finding. Moreover, Reed and Means (2004) found that participants, performing a category-learning task, responded slower on successive trials when the value of task-irrelevant stimulus dimensions changed, relative to when these values did not change across trials. Interestingly, this manipulation of

task-irrelevant dimension values affected task performance without the participants having any explicit memory for these values. In other words, implicit or unconscious information processing does appear to play an important role in sorting or category-learning tasks. And this, of course, would be completely in contrast with the generally accepted view that thinking, executive functions, and the WCST all are associated with controlled, conscious processing.

Regardless of these theoretical and empirical considerations, it is striking how a procedure, developed by Narziss Ach to investigate thinking, and also used for this purpose by Goldstein and others in neurological and psychiatric patients, is regarded by the behaviorist-oriented Grant, Harlow, and Berg as a quantitative procedure for examining discrimination learning. In subsequent neuropsychological research, it (again) has been used as a test for executive functions (i.e., thinking), now relying on the quantitative results rather than the qualitative analysis of a subject's attitude. However, recent findings suggest we may yet return to an associative network approach, developed within the behaviorist tradition.

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