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WHAT WE THOUGHT WE KNEW: INTELLECTUAL ASSESSMENT OF INDIVIDUALS WHO ARE BLIND

by

Richard L. Sylvester, Jr., B.S., M.A.

A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

COLLEGE OF EDUCATION
LOUISIANA TECH UNIVERSITY

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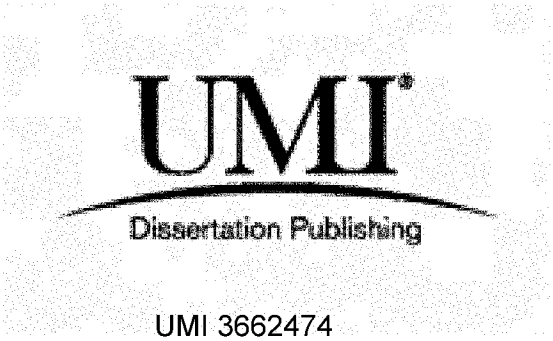

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ABSTRACT

Throughout the history of intellectual assessment, research involving individuals who are blind has often been scarce. Currently, there are no intellectual assessment procedures based on the Cattell-Horn-Carroll (CHC) theory of intelligence available to individuals who are blind. CHC theory is considered to be the gold standard of intellectual assessment and many government and diagnostic policies rely upon CHC theory. The proposed research sought to extend the current reach of CHC theory to individuals who are blind by developing a new measure of tactile performance ability. The Tactile Assessment of Performance (TAP) was developed and administered to participants who were blind and participants who were sighted. A total of 64 participants completed the research procedure, 32 participants who were sighted and 32 participants who were blind. A modified multitrait-multimethod design was employed. Most of the TAP subtests correlated positively with the Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV), which is a widely used and accepted measure of intellectual functioning. The subtests of the TAP failed to correlate with measures of achievement striving and conscientiousness, which is indicative of discriminant validity. Results suggest the TAP is capturing aspects of CHC abilities and may prove useful as a measure of intelligence in individuals who are blind.

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DEDICATION

To my loving, wonderful wife, Kelsey, who has always been there for me and provided unwavering love and support.

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CHAPTER ONE

INTRODUCTION

An individual's intellectual functioning has been conceptualized as a single entity (Wechsler, 1944 & 1955), and also as multiple different abilities with researchers (e.g., Gardner, 2004; Guilford, 1967; McArdle & Woodcock, 1998; Sternberg, 2005) believing defining and measuring different types of intelligence was not something with which everyone should be concerned. However, according to the American Psychiatric Association (APA: 2000), Lichtenberger and Kaufman (2009), and Gregory (2007), in the research and practice of psychology there were times during which the ability to capture a person's intellectual functioning is of great importance, such as determining an individual's strengths and weaknesses, ruling out learning disorders or mental retardation, and investigating the possibility of cognitive disorders. An additional problem arises in the assessment of intellectual functioning in that people were not all the same in regards to the approaches used in assessment. The APA (2000), as well as other researchers (e.g., Gardner, 2004; Lichtenberger and Kaufman, 2009; Sternberg, 2005), emphasized the importance of selecting and interpreting assessment measures appropriate to individuals based on culture, language, physical limitations, personal history, and mental state.

The goal of the current research was to adapt an approach to assessing intellectual functioning to meet the needs of an often underrepresented population. More specifically,

current measures of intellectual functioning have limited use in populations of individuals who were blind. There was no measure available that fully applied the current theory of intellectual assessment to address the specific needs of individuals who were blind. The current research sought to examine this issue.

Modern intellectual assessment began with the work of Charles Spearman (1904) around the turn of the 20th century. Numerous scientists and researchers were interested in the definition and measurement of intelligence, but there was considerable disagreement as to what exactly defined intelligence and even more disagreement as to how intelligence should be measured. Spearman provided a review of attempts to capture intellectual functioning based on physical measurements as well as attempts requiring participants to complete various tasks. In short, the field of intellectual assessment was growing quickly, but it lacked focus or direction. Fortunately for everyone in the realm of intellectual assessment and psychology, Spearman was quickly becoming a renowned scientist and researcher who would go on to become one of the greatest leaders in the field of intellectual assessment and one of the most influential scientists in the realm of psychology.

Defining and Measuring Intelligence: Spearman

Lichtenberger and Kaufman (2009) reported dozens of psychologists had attempted to measure and define intelligence, but those attempts have yielded varied results. Spearman (1904) wrote a ground breaking article regarding the definition and measurement of intelligence. He not only defined and measured general intelligence, but he also challenged every scientist who had attempted to measure general intelligence up to that point in time. Spearman launched a thorough criticism on the methods and

theories of more than a dozen scientific researchers. He identified the faults in methodology ranging from sampling bias to poor instrumentation. Spearman's idea regarding the definition and assessment of general intelligence involved sensory discrimination.

Spearman (1904) believed that sensory discrimination abilities were directly related to general intelligence. His first reason for using sensory discrimination was because he could control and manipulate his apparatus easily and it was an objective, scientific measure. His second major reason for using sensory discrimination was that it had been used by previous researchers and was an established means of attempting to measure intelligence. Spearman's methods were somewhat similar to those of previous researchers, but he provided more objective measures of the senses and produced such great detail of his work that it could be easily replicated.

He attempted to measure and define general intelligence by means of three of the five senses: visual, auditory, and tactile. He asked his participants to discriminate between different shades of light, different levels of pitch, and different weights held in the hand. He correlated his or her performance on those different abilities with his or her school grade classification and whether he or she were bright, dull, or average as rated by his or her teachers. Spearman found significant positive correlations across all three realms of sensory discrimination and advanced ratings or placements in school. In other words, Spearman found that participants who were good at providing accurate accounts of sensory discrimination at visual, auditory, and tactile tasks were also performing well in academic endeavors.

The conclusions he reached indicated that some of what his participants were able to produce seemed to be heavily influenced by age or school learned knowledge, but he also discussed what he called "native capacity" and "common sense" (Spearman, 1904, p. 251). He talked about native capacity as academic ability that seemed unrelated to the age of a participant. He referred to common sense as the ability a participant possessed concerning knowledge not learned in school, but had great value regarding different judgments one would make throughout their life. Spearman went on to define general intelligence "As regards the delicate matter of estimating 'Intelligence,' the guiding principle has been not to make any *a priori* assumptions as to what kind of mental activity may be thus termed with greatest propriety. Provisionally, at any rate, the aim was empirically to examine all the various abilities having any *prima facie* claims to such title, ascertaining their relations to one another and to other functions" (p. 249-250).

More than 100 years after Spearman's initial venture into the world of intellectual assessment, Deary, Bell, Bell, Campbell, and Fazal (2004) were testing his theory and finding evidence to support his work. Deary et al. (2004) employed numerous short-form measures of intelligence when investigating participant's abilities to discriminate between differing weights, colors, and pitch. They found strong, positive correlations between the measures of intelligence and the measures of sensory discrimination.

Francher (1985) reported Spearman's research laid the groundwork for future researchers and scientists who desired to tread into the field of intellectual assessment. However, Francher asserted he was not the only great scientist attempting to define and measure intellectual functioning. Francher stated that while Spearman was working on defining the specific factors and contributors to intellectual functioning, another scientist

named Alfred Binet was working with French schoolchildren and attempting to differentiate normal functioning children from those who might be classified as mentally retarded.

Defining and Measuring Intelligence: Binet

Francher (1985) reported that in 1904, Binet was commissioned by a group of French professionals to develop and implement a method of distinguishing mentally retarded schoolchildren from normal functioning schoolchildren. Binet ran into a problem: there were no validated measures of intellectual functioning in children at the time. Binet and Simon (1916) defined intelligence by saying "there is a fundamental faculty, the alteration or lack of which, is of the utmost importance for the practical life. This faculty is judgment, otherwise called good sense, practical sense, initiative, the faculty of adapting one's self to circumstances" (p. 198). They went on to add, "A person may be a moron or an imbecile if he is lacking in judgment; but with good judgment he can never be either. Indeed the rest of the intellectual faculties seem of little importance in comparison with judgment" (p. 198).

In 1916, Binet and Simon published what was dubbed the Binet-Simon Scale for children of various ages. They reported that the development of items and subtests on the scale were based mostly on observations of children and expertise in the area of developmental psychology. The Binet-Simon Scale consisted of thirty different subtests to be administered in a specific order so that subtest difficulty started at a very basic, easy level and increased in difficulty. Binet and Simon suggested that if a child could successfully complete the 30th subtest, then the child was likely of average intelligence or higher. They designed the scales to be easily understood by children, but also easy and

quick to administer. However, it may be worth noting that the Binet-Simon Scale was composed of roughly three times the number of subtests that make up the current gold standard intelligence measures.

According to Binet and Simon (1916), prior to administration of the individual subtests of the Binet-Simon Scale, the examiner was required to read a set of standardized instructions to the participant. Further, Binet and Simon said the examiner was instructed to build rapport with the participant, make sure the participant was motivated to successfully complete the tasks, and attempt to make the participant comfortable with the testing situation. In specifying all these details and instructions of administration, Binet and Simon set the standard for nearly all future measures of intelligence. Today test researchers and administrators recognize the importance of the participant being motivated and comfortable with the testing situation (Lichtenberger & Kaufman, 2009), but Binet and Simon (1916) knew and reported the importance of such things prior to there being a great deal of research on factors that influenced testing.

Overall, the Binet-Simon Scale (1916) seemed to place a great deal of emphasis on the participant's abilities in the areas of attention, vocabulary, visual processing, and verbal reasoning with minor emphasis on mental quickness and sensory discrimination. These abilities were somewhat consistent with those discussed by Spearman (1904) and seemed to support his work. It was also worth noting two major flaws in the Binet-Simon scale. The first flaw was a lack of standardized items and instructions. At some points during the testing procedure the examiner was required to simply make up a series of numbers or create a way of explaining a subtest to a participant. Binet and Simon seemed

to work under the assumption that the examiner had a great deal of experience working with children, which might be a dangerous assumption to have made.

The second major flaw in the design of the Binet-Simon Scale (1916) was that of the thirty different subtests only one of them had a description of a viable testing procedure to gauge the abilities of individuals who were blind. In an article of more than fifty pages, Binet and Simon (1916) devoted only one sentence to the intellectual assessment of individuals who were blind. With so little emphasis placed on the assessment of individuals who were blind, it was little wonder that a formal, full assessment of the intelligence of individuals who were blind was nearly sixty years away.

Not only was an assessment procedure for individuals who were blind nearly sixty years away, it was also an ocean away, literally. Binet and Simon (1916) had conducted their work in France. Of course, their test and norms were based on the French culture and standards. One could not expect the French culture and standards to be the same as those of the United States. The monumental task of translating the Binet-Simon Scale and adapting it for use on the U.S. was undertaken by Lewis Terman.

Terman's (1916) adaptation of the Binet-Simon Scale was known as the Stanford-Binet and was still in use today, though it had been revised several times. His work was a significant first step in furthering development of intelligence assessments. In addition, his devotion to the study of intelligence across the lifetime may have inspired future scientists to investigate the assessment of intellectual functioning in a new manner. Up until this point in history intellectual assessment had been mostly concerned with the functioning of children and relatively little work had focused on capturing the intellectual

abilities of adults. However, with the coming of World War II and the needs of armed forces to be considered, that would soon change.

According to Lichtenberger and Kaufman (2009), David Wechsler began his career as a psychologist working for the U.S. Army. They reported that during his career with the Army, Wechsler was highly involved with intellectual assessment and the Army Alpha and Army Beta exams. Lichtenberger and Kaufman (2009) indicated Wechsler worked closely with some of the greatest minds of the assessment world, including Spearman. Wechsler (1940) developed a deep understanding and appreciation of Spearman's work, but he was not satisfied with it and sought to extend it.

Defining and Measuring Intelligence: Wechsler

Kaufman and Lichtenberger (2005) conducted a review of the history of intellectual assessment and reported it was widely accepted that Spearman's work and the development of the Binet-Simon Scale and later the Stanford-Binet set forth the groundwork on which future scientists would base their work in the realm of intellectual assessment. They said another influential scientist in the realm of intellectual assessment was Wechsler. According to Kaufman and Lichtenberger (2005), Wechsler was well known for many aspects of intelligence testing, but he began his career working in the army assessing the intelligence of new recruits via his Army Alpha and Army Beta intelligence measures. Wechsler (1944) defined intelligence as "Intelligence is the aggregate or global capacity of the individual to act purposefully, to think rationally and deal effectively with his environment" (p. 3).

Wechsler (1955) designed the original version of the Wechsler Adult Intelligence Scale (WAIS) based off the work of previous scientists. He conceptualized intelligence as

falling into two broad domains: verbal and performance. In a review of Wechsler's work, Kaufman and Lichtenberger (2005) asserted that from the verbal and performance indices one was able to calculate the full scale intelligence quotient (FSIQ).

Kaufman and Lichtenberger's (2005) review of Wechsler's work indicated the verbal portion of the original WAIS was composed of six individual subtests. They reported the information subtest of the verbal scale was designed to test the participant's general range of knowledge by asking questions related to school learned, culturally influenced facts. The next test on the verbal portion of the WAIS was digit span, which tasked the participant to recall a string of numbers forward and backward. After that came the vocabulary subtest that required participants to recall definitions of various words. Wechsler believed that vocabulary ability was related to progress in academics as well as general intellectual functioning. The next subtest was the arithmetic subtest which investigated the participant's mathematical ability without the use of pencil, paper, or calculator. After that the comprehension subtest was administered which measured a participant's general factual knowledge, knowledge of social norms, and also allowed for the detection of some psychotic conditions and personality problems. The final subtest in the verbal index was similarities, which measured a participant's abstract verbal reasoning abilities by asking him or her to explain how two words were alike even though they might seem very different on the surface.

Kaufman and Lichtenberger (2005) reported the performance index of the WAIS was composed of five subtests. The first subtest of the performance index was picture completion which, required the participant to identify the missing part of an object while under a time constraint. The second subtest of the performance index was the picture

arrangement subtest, which required the participant to assemble a series of pictures in a manner that told a coherent story while under a time constraint. The third subtest was block design, in which a participant would be required to recreate designs via blocks while under a time constraint. Object assembly was the fourth subtest of the performance index and it required participants to assemble puzzle pieces to form different objects or shapes while under a time constraint. The final subtest on the performance index was digit symbol-coding, which tasked participants to copy a number of different symbols associated with specific numbers via pencil and paper while under a time constraint.

Lichtenberger and Kaufman (2009) pointed out that Wechsler's intellectual assessment measures had gone through several revisions, but were still among the gold standard of intelligence tests used today. Further, the Wechsler series of intelligence tests have remained very similar to one another over the years. The norms have been updated and a few subtests have been added and/or removed, but the same basic design of subtests being combined into index scores, which are then combined with other index scores to form the FSIQ had remained the same. The original WAIS was an amazing measure for its time and might have captured a couple of constructs that Wechsler may not have originally intended to capture: crystallized and fluid intelligence.

Different Types of Intelligence

According to Gregory (2007), intelligence could be thought of as the ability to adapt to a situation or environment and learn from past experiences. Given this definition, it is easy to see how intelligence would be a desirable feature; however, McArdle and Woodcock (1998) suggested that there is more than just one type of intelligence. McArdle and Woodcock indicated there are multiple different types of intelligence that

humans were able to apply sometimes separately and sometimes in unison. Murdoch (2007) stated that for many years there had been controversy surrounding the measurement of intelligence and the practical applications of those measures. However, McArdle and Woodcock (1998) suggested most researchers agreed upon the existence of at least two types: crystallized intelligence and fluid intelligence.

Horn and Cattell (1967) developed the concept of crystallized and fluid intelligence more than 40 years ago, but the two concepts were extremely influential on modern intellectual assessment. Lichtenberger and Kaufman (2009) suggested those concepts were still considered in the development of intelligence tests today. Going by their original theory, Horn and Cattell (1967) developed nine total broad abilities, but crystallized and fluid intelligence seem to be the most heavily researched. In addition to crystallized and fluid intelligence, Horn and Cattell's research discussed the broad abilities of quantitative knowledge, reading/writing, visual-spatial thinking, auditory processing, long-term retrieval, short-term retrieval, and processing speed. Their model was heavily derived from factor analytic research; however, it was worth noting that Horn and Cattell did not support the idea of a single overall factor indicative of general intelligence.

Flanagan and Kaufman (2004) indicated crystallized intelligence had been defined as cultural knowledge that had been accumulated over time and also referred to the application of that knowledge. Flanagan and Kaufman also pointed out that crystallized intelligence can refer to things a person had learned in school and uses when necessary (e.g., vocabulary and the proper definition and application of terms). As previously mentioned, the measurement of crystallized intelligence was somewhat

controversial, depending upon the application of the measures, but common methods for measuring crystallized intelligence for research purposes often included word definition tasks and figure matching tasks (e.g., Marsiske & Margrett, 2006; Marsiske & Willis, 1995; McGrew & Hessler, 1995; Murdoch, 2007). According to Flanagan and Kaufman (2004), crystallized intelligence was a well-researched construct that was heavily relied upon when calculating full scale intellectual functioning for several common intelligence tests.

Flanagan and Kaufman (2004) stated fluid intelligence (also called fluid reasoning) had been defined as an individual's ability to confront novel problems and create or figure out novel solutions to those problems. In addition, they said fluid intelligence dealt with more of an individual's ability to figure out abstract concepts and apply abstract reasoning skills when compared to crystallized intelligence. As with crystallized intelligence, the measurement of fluid intelligence was somewhat controversial, but the measurement of fluid intelligence for research purposes often involved some type of abstract reasoning task such as completing puzzles or patterns, solving abstract math computations, and the general application of concepts to novel situations in some form of abstract manner, possibly through the use of vignettes (e.g., McGrew & Hessler, 1995; Murdoch, 2007; Prabhakaran, Smith, Desmond, Glover, & Gabrieli, 1997).

Through the years of research, numerous studies revealed some consistent trends regarding crystallized and fluid intelligence in humans (e.g., Flanagan & Kaufman, 2004; Gregory, 2007; Kaufman & Lichtenberger, 2005; McArdle & Woodcock, 1998). McArdle and Woodcock (1998) pointed out that one of the more consistent findings

related to fluid intelligence was that it seemed to decline with age, in terms of raw intellectual power; however, normative research and statistical adjustments kept the calculated score more constant. Kaufman and Lichtenberger (2005) reported that fluid intelligence, as measured by an individual's ability to reason abstractly in terms of verbal concepts and solve for patterns by using different letters, declined at a rate of approximately four intelligence points per decade. To better comprehend this decline it was best to understand how most measures conceptualized intelligence scores. Kaufman and Lichtenberger stated the vast majority of intelligence tests used a standard score system for interpreting intelligence test results. Further, this standard score system used one-hundred as the average score with a fifteen point standard deviation. Hence, over a period of a little more than thirty years an individual's intelligence score would decline by one standard deviation. McArdle and Woodcock suggested that fluid intelligence began to decline in the early to mid-twenties.

Research noted the decline of fluid intelligence with age, but Kaufman and Lichtenberger (2005) also documented the increase of crystallized intelligence with age. They measured crystallized intelligence via a verbal analogy task and a definition task. Their results revealed that crystallized intelligence increased by two intelligence points per decade. Further, their results indicated that crystallized intelligence began to increase during the mid-twenties, which was also the time fluid intelligence began to decrease.

As previously mentioned, Kaufman and Lichtenberger (2005) described crystallized intelligence as related to the knowledge accumulated over the lifetime and fluid intelligence as the individual's ability to reason abstractly and solve novel problems. Put simply, it seemed that as people accumulated more knowledge across the lifetime, he

or she used it more and more. In other words, as one's life experience builds, he or she relied more on that experience to complete the challenges of life. Some researchers might say that an individual's problem solving abilities based in crystallized intelligence increased as his or her available schemata also increased (e.g., Gick, 1986; Marsiske & Margrett, 2006; Marsiske & Willis, 1995). Further, Gick (1986) said given that the individual's problem solving schemata for a particular area developed more; (i.e., he or she developed more expertise), he or she would be required to rely on novel problem solving skills, the abstract reasoning associated with fluid intelligence, less and less.

The concepts of crystallized and fluid intellectual abilities greatly advanced the world of intellectual assessment; however, as with any good, true science the field of intellectual assessment was constantly evolving. Carroll (1993) took the ideas of crystallized and fluid intelligence and expanded upon them greatly via his factor analytic studies. He presented a new way of conceptualizing intelligence built on the extension of previous theory and termed it the three-stratum theory. Carroll (1993) said: "there are a large number of distinct individual differences in cognitive ability, and relationships among them derived by classifying them into three different strata: stratum I, 'narrow' abilities; stratum II, 'broad abilities; and stratum III, a single 'general' ability" (p. 122).

Cattell-Horn-Carroll Three Stratum Model of Intelligence

The concepts of crystallized and fluid intelligence as well as the other Cattell-Horn broad intellectual abilities served the assessment community quite well, but in 1993, Carroll extended the Cattell-Horn model and transformed it into the three-stratum model. His three-stratum model came about via a massive meta-analysis that revealed 69 specific abilities Carroll called stratum I, 8 broad abilities that made up stratum II which

included fluid intelligence, crystallized intelligence, general memory and learning, broad visual perception, broad auditory perception, broad retrieval ability, broad cognitive speediness, and processing speed, and one higher order factor that Carroll termed general intelligence, stratum III.

Carroll (1993) decided to combine models to form the Cattell-Horn-Carroll (CHC) theory of intelligence. Kaufman and Lichtenberger (2005) reviewed the combined theories which produced eight total broad abilities including: crystallized intelligence, fluid intelligence, quantitative knowledge, short-term memory, long-term storage and retrieval, auditory processing, visual processing, and cognitive processing speed. They reported that CHC was similar to both Cattell and Horn's work as well as Carroll's work, but the union of the two focused mainly on the broad abilities, stratum II of Carroll's theory. In addition, Kaufman and Lichtenberger (2005) pointed out the first and third stratum of Carroll's theory were not included in the CHC theory as neither of those stratum had a place in Cattell-Horn theory. However, the concept of a single number indicative of overall intellectual functioning was quite popular and was used for numerous purposes (e.g., APA, 2000, Flanagan & Kaufman, 2004; Kaufman & Lichtenberger, 2005).

Carroll's (1993) writings indicated CHC theory was a tremendous addition to the world of intellectual assessment, but it was not the only conceptualization of intellectual functioning. He said it built on the idea that there could be multiple different forms of intelligence. However, the idea of multiple intelligences was hardly a new concept when Carroll introduced his three-stratum theory.

Multiple Forms of Intelligence

Other scientists also endorsed the idea of multiple form of intelligence similar to the broad abilities of the CHC theory, but did not support the idea of a single number indicative of overall functioning (e.g., Flynn, 2009; Gardner, 2004; Guilford, 1967). Guilford (1967) was one of the first psychologists to denounce the use of intelligence tests that sought to reduce the functioning of a person down to a single number. He postulated that there were more than one-hundred different abilities across three dimensions that could be considered a part of intellectual functioning. Guilford's Structure of Intellect (SI) model consisted of Content, Products, and Operations dimensions and was often displayed as a cube with each dimension composing a side. He suggested that intelligence was much more complex than a single ability or number could possibly demonstrate and his SI model was fluid enough that new abilities could be discovered and added. Guilford's (1982) ideas and SI model helped change the way many people perceived intelligence and opened the way for other theorists to research multiple forms of intelligence.

According to Kaufman and Lichtenberger (2005), many psychologists and researchers were likely influenced by Guilford's work and one of the most notable would be Gardner, who furthered the idea of intelligence being composed of more than one type of ability. Gardner (2004) reported his theory of multiple intelligences which included: linguistic intelligence, musical intelligence, logical-mathematical intelligence, spatial intelligence, bodily-kinesthetic intelligence, and personal intelligence, but there were two sub-categories under personal intelligence which were self-oriented personal intelligence and other-directed personal intelligence. Gardner (2004) and Flynn (2009) both made the

points that current intelligence tests that sought to capture a Full Scale Intelligence Quotient (FSIQ) might be short changing people by overlooking other potential aspects of intelligence. Flynn (2009) asserted the possibility of a person being gifted musically, but still performing poorly on most intelligence tests simply because the tests were more concerned with verbal and mathematical ability. In addition, Gardner (2004) pointed out that the current gold standard intelligence measures would overlook the concept of bodily-kinesthetic intelligence because those measures rarely involve an athletic ability measure or measures of bodily coordination. To further complicate the difficult situation created by Gardner's concept of multiple intelligences, Flynn (2009) asserted there were no popular, well-validated measures that captured all aspects of the multiple intelligences presented in his theory. In addition, many agencies seemed to prefer the idea of a FSIQ to indicate the overall functioning of a person via a single number (e.g., APA, 2000; Flanagan & Kaufman, 2004; Kaufman & Lichtenberger 2005).

Further, Sternberg (2005) provided a different, more applied version of the definition of intelligence that likely would not be captured by the current gold standard intellectual assessments. Sternberg (2005) suggested that intelligence was "1) ability to achieve one's goals in life, given one's sociocultural context; 2) capitalizing on strengths and correcting/compensating for weaknesses; 3) to adapt, shape, and select environments; and, 4) through a combination of analytical, creative, and practical abilities" (p. 189). His theory encompassed analytical intelligence, creative intelligence, and practical intelligence, the Sternberg triarchic theory. He also developed a way to measure these different types of intelligences and dubbed it the Sternberg Triarchic Abilities Test (STAT) and sought to verify his theory via empirical means. His results indicated support

for his triarchic model of successful intelligence, but many had not received the model well and it did not provide a FSIQ which would be required to be accepted by schools and other government agencies for diagnostic purposes. However, some scientists supported Sternberg's work because it was consistent with the idea of multiple intelligences and was vaguely similar to the broad abilities discussed in the CHC theory (e.g., Gregory, 2007; Kaufman & Lichtenberger, 2005).

Kaufman and Lichtenberger (2005) reported the concept of multiple intelligences had generated considerable research support, but one of the major drawbacks to Sternberg and Gardner's work was that it failed to yield a well-validated FSIQ. Lichtenberger and Kaufman (2009) indicated the FSIQ was certainly not the perfect indication of intellectual functioning, but suggested it was the best overall measure of intellectual functioning available when making use of measures built around CHC theory.

Full Scale Intelligence Quotient

The concept of a single number indicative of overall function was often sought out by schools and government agencies to aid in the diagnoses and placement of individuals, and the FSIQ was usually the number with which those entities were most concerned (e.g., APA, 2000; Flanagan & Kaufman, 2004; Kaufman & Lichtenberger, 2005; Lichtenberger & Kaufman, 2009). Kaufman and Lichtenberger (2005) reported intellectual functioning was often measured for the purposes of research as well and compared to other abilities or personality characteristics. Several agencies used the FSIQ as an overall indicator of functioning by which a person's disability status may be determined and in some instances the FSIQ was compared to other measures of cognitive functioning to determine whether a person may be considered learning disabled (e.g.,

APA, 2000; Flanagan & Kaufman, 2004; Kaufman & Lichtenberger, 2005; Lichtenberger & Kaufman, 2009). Further, performance on intelligence measures often influenced whether a person might be diagnosed with attention deficit-hyperactivity disorder and what type of accommodations mighty best suit that person (APA, 2000; Flanagan & Kaufman, 2004). This raised an interesting problem regarding the people who could not complete all portions of the gold standard intelligence measures.

Intellectual Assessment: One Size Does Not Fit All

Flynn (2009) asserted that one could not assume a person was lacking in intelligence simply because the person could not complete all portions of an intellectual assessment. He continued by indicating this was further complicated when one considered that even gold standard intelligence assessments were likely not capturing every factor that made up human intelligence. Consider the following example: if an individual who was blind were to attempt to complete the Wechsler Adult Intelligence Scale Fourth Edition (WAIS-IV; The Psychological Corporation, 2008) that person would only be able to complete roughly half of the measure and therefore would not be able to obtain a FSIQ (Lichtenberger & Kaufman, 2009). Without a completed WAIS-IV and accompanying FSIQ, the individual who was blind would potentially not be able to fit into the criteria for a diagnosis of learning disabled or attention deficit-hyperactivity disorder (APA, 2000; Lichtenberger & Kaufman, 2009). Based on the writings of Lichtenberger and Kaufman (2009), one could reason that if individuals who were blind were somehow magically immune to problems related to attention deficit-hyperactivity disorder or learning disabilities, then this would not be a problem, but the way

intelligence measures were used and the FSIQ calculated and applied, individuals who were blind were put at a huge disadvantage.

The International Council of Ophthalmology (2002) defined legal blindness as a visual acuity of 20/200 or less in the best functioning eye. Further, their writings indicated legal blindness represented a full spectrum of functioning beyond the 20/200 level of visual acuity. In other words, all individuals who were legally blind were not created equal. One person who was legally blind might be able to detect small amounts of light or detect shadows while another person who was legally blind might have no vision. However, Boven, Hamilton, Kauffman, Keenan, and Pascual-Leone (2000) reported it was important to remember that an individual who was legally blind remained a capable, resourceful human being. In truth, individuals who were blind might possess superior skills to persons who were sighted, in specific skill areas.

Boven et al. (2000) conducted research in the area of spatial resolution in persons who were blind and persons who were sighted. They focused on detection of changes in textures perceived through the participants' index fingers. Further, there was a significant difference in the tactile discrimination abilities of individuals who were blind and individuals who were sighted, but blindfolded. Individuals who were blind consistently demonstrated higher scores on measures of tactile ability than individuals who were sighted, but blindfolded. In addition, the researchers reported similar findings had been found in similar tasks throughout the scientific literature. They explained that when an individual who was sighted was blindfolded the person went into a state of shock due to the loss of vision and required nearly an hour to readjust to the new sensory experience. As one could imagine, this made the task of comparing the abilities of individuals who

were blind and individuals who were sighted but blindfolded quite difficult. This problem was further exacerbated by a lack of valid measures of the abilities of individuals who were blind in the area of intellectual assessment.

Though the existing research available on human intellectual abilities was expansive and quite thorough, some groups of individuals have been overlooked. One often overlooked group in many areas of psychological research was individuals who were blind (Beal & Shaw, 2008; Flanagan & Kaufman, 2004). Lichtenberger and Kaufman (2005 & 2009) provided a review of many intellectual assessment instruments and there was no comprehensive evaluation of intelligence based on CHC theory designed and normed for use with a population of individuals who were blind. However, they mentioned measures of fluid and crystallized intelligence often used in research, such as verbal recognition or definition tasks and verbal abstract reasoning tasks should remain applicable to a population of individuals who were blind. Further, Mettler (1995) pointed out research had been conducted investigating the cognitive abilities of individuals who were blind.

Cognitive Abilities and Individuals Who Are Blind

Overall, Mettler's (1995) research suggested that the cognitive ability process used by individuals who were blind was very similar to the problem solving process used by individuals who were sighted. However, there was no indication in Mettler's work that cognitive abilities in populations of individuals who were blind had been conceptualized in terms of fluid and crystallized intelligence and there was no indication that research had been conducted to investigate potential differences between younger and older

individuals. However, there was research available conducted by Sanchez and Saenz (2006) investigating cognitive abilities in children who were blind.

Sanchez and Saenz (2006) investigated how children who were blind interacted in third dimensional sound environments in terms of problem solving skills. The basic premise of their research was to use sounds to enhance the cognitive skills and problem solving abilities of children who were blind. Their results indicated they were able to adapt and learn in the new sound environment and increased everyday problem solving skills. However, Sanchez and Saenz (2006) did not conceptualize their measures in terms of crystallized or fluid intelligence. Though the measures were not clearly defined in terms of intelligence, one was able to read through the measures and observe that they call for the children to adapt to new situations and seem to imply fluid intelligence being used over crystallized intelligence. If this was true, then it would be similar to findings regarding problem solving and crystallized and fluid intelligence in sighted children. However, one cannot assume those findings would carry over into adulthood.

Haptic Test Battery

Though the topic of intellectual assessment in adult individuals who were blind had been overlooked during the past 50 years, Ballesteros, Bardisa, Millar, and Reales (2005) investigated and attempted to capture the construct of intelligence in children who were blind. They developed a test battery to measure the tactile abilities of children who were blind or visually impaired ages 3 to 16 years old. Their Haptic test battery consisted of 20 subtests which measured a total of six different factors that included: spatial comprehension, short-term memory, object identification, raised shape identification, sequential scanning and longer-term coding for new objects, but through factor analysis

four of the subtests were removed from the overall battery. Sadly, the researchers did not compare the factors described in their results to those of the CHC theory, but a closer inspection of the Haptic subtests that made up make the haptic factors might reveal some similarities to the CHC factors.

Ballesteros et al. (2005) reported the spatial comprehension factor of the Haptic was composed of the dimensional structure, spatial orientation, graphs and diagrams, symmetry raised lines, symmetry surfaces, symmetry objects, and longer-term recognition subtests. Their dimensional structure subtest required participants to touch an object and then find a matching object in a series of stimuli. The graphs and diagrams subtest required children to continuously scan a raised line, indicate high and low points, and find and identify points. The spatial orientation subtest required participants to recognize different shapes and identify the similar shapes in a series of stimuli. The symmetry detection subtest required participants to judge whether objects were similar based on raised lines, surfaces, and the shape of objects. The longer-term recognition subtest required children to correctly determine whether they had been previously exposed to an object after a five-minute time delay. Though there was no existing research to confirm it, the subtests in the Haptic spatial comprehension factor seemed similar to the CHC broad abilities of fluid intelligence, long-term storage and retrieval, and cognitive processing speed discussed by Carroll (1993).

The short-term memory factor of Ballesteros et al.'s (2005) Haptic was made up of the material and texture discrimination, dot span, object span, and movement span subtests. In the material and texture discrimination subtest the child was required to correctly determine the material a shape was made of (wood, iron, sandpaper, cloth,

rubber, or cardboard) and the texture of the sandpaper on the shape to match the shape presented by the examiner. In the dot span subtest the child was required to correctly identify the number of dots on a series of dominoes. The object span subtest was somewhat similar to the dot span subtest, but it required the child to correctly identify a series of shapes instead of dots. The movement span subtest required that the child identify and mimic the movements of the examiner's hands. Overall, the short-term memory factor of the Haptic seemed to be similar to the cognitive processing speed and short-term memory abilities of the CHC theory, but there was no research to support this thought other than Carroll's (1993) work regarding CHC.

The object identification factor of Ballesteros et al.'s (2005) Haptic was composed of the incomplete objects and object naming subtests. The incomplete objects subtest asked children to correctly identify a series of common objects that were missing features. The object naming subtest required children quickly and accurately identify a series of common objects. This portion of the Haptic seemed to tap into some of the CHC theory related to crystallized intelligence and cognitive processing speed, but there was no research to support this thought again other than Carroll's (1993) work regarding CHC.

The raised-shape identification factor of Ballesteros et al.'s (2005) Haptic consisted of the figure-ground discrimination and incomplete shapes subtests. The figure-ground discrimination subtest asked children to identify a shape through tactile perception though the shape was partially obscured. The incomplete shapes subtest required children to verbally identify shapes and objects through tactile perception. This factor of the Haptic seemed to tap into some of the crystallized intelligence abilities of

the CHC theory, but there was little research evidence to support this statement other than Carroll's (1993) work regarding CHC.

The sequential scanning factor of Ballesteros et al.'s (2005) Haptic consisted of only one subtest: efficient dot scanning. The efficient dot scanning subtest required children to quickly scan and point to dots on a page. This factor seemed to tap into some of the CHC ability termed cognitive processing speed and perhaps a little fluid intelligence, but again there was little research available to support this statement other than Carroll's (1993) work regarding CHC.

The final factor of Ballesteros et al.'s (2005) Haptic was longer-term coding for new objects, which consisted of the material and texture discrimination and longer-term recognition subtests. As previously mentioned, in the material and texture discrimination subtest the child was required to correctly determine the material a shape was made of (wood, iron, sandpaper, cloth, rubber, or cardboard) and the texture of the sandpaper on the shape to match the shape presented by the examiner. Again, as previously mentioned the longer-term recognition subtest required children to correctly determine whether they had been previously exposed to an object after a five-minute time delay. This factor of the Haptic seemed to correspond with the long-term storage and retrieval and cognitive processing abilities of the CHC theory, but there was little research based evidence to support this statement other than Carroll's (1993) work regarding CHC.

Ballesteros et al.'s (2005) Haptic appeared to be a good starting point for the intellectual assessment of children who were blind, at the very least. However, one cannot assume that such a test would work just as well with adults as it did with children. Further, the Haptic did not produce a single number score comparable to the FSIQ. In

order to better understand what was needed to calculate the FSIQ of an adult individual, one must focus on one of the gold standard adult intelligence measure.

Wechsler Adult Intelligence Scale – 4th Edition

The Wechsler series of adult intelligence scales has long been considered the gold standard by which scientists and practitioners gauge intelligence (Flanagan & Kaufman, 2004; Kaufman & Lichtenberger, 2005; Lichtenberger & Kaufman, 2009). The WAIS-IV was the current flagship in the realm of adult intellectual assessment measure for the Wechsler series (Kaufman & Lichtenberger, 2009; The Psychological Corporation, 2008). The Psychological Corporation (2008) reported the WAIS-IV consisted of 15 individual subtests, of which five were optional, and produceed four index scores: the verbal comprehension index, the working memory index, the perceptual reasoning index, and the processing speed index. They further said the four index scores were combined to calculate the FSIQ of an individual; however, the individual's age was also considered in this calculation.

The WAIS-IV was often used in research as well as clinical settings. Laidra, Pullmann, and Allik (2007) demonstrated a weak, positive correlation between intellectual functioning and GPA. Moutafi, Furnham, and Paltiel (2004) investigated how intellectual functioning was related to personality characteristics such as conscientiousness and need for achievement. Their research indicated there a weak, negative relationship between verbal intelligence and conscientiousness that did not persist when compared to performance-based measures of intelligence. Furnham, Chamorro-Premuzic, and McDougall (2003) found a weak, negative relationship between verbal intelligence and need for achievement, but that correlation disappeared when

considering performance-based measures of intelligence. However, to fully understand the WAIS-IV and its many uses, one must first be familiar with the different components of the measure.

The Psychological Corporation (2008) provided materials with the WAIS-IV which explained that the verbal comprehension index was composed of four subtests: similarities, vocabulary, information, and comprehension, the optional subtest. The similarities subtest required participants to listen to the examiner say two words and then verbally tell the examiner how the two words were alike. The subtest was considered to mostly be a measure of the CHC theory ability crystallized intelligence via abstract verbal reasoning. The vocabulary subtest required participants to listen as the examiner asked them to define a word and then provide a correct verbal definition of the word. The subtest was considered to be a measure of the CHC theory ability crystallized intelligence. The information subtest required participants to listen as the examiner asked him or her questions based on general factual knowledge. The subtest was considered to be a measure of the CHC theory ability crystallized intelligence. The final subtest of the index was comprehension, which required the participant listen as the examiner asked him or her questions related to knowledge of factual information and social norms. This test was optional, but was considered to be a measure of the CHC theory ability crystallized intelligence. Kaufman and Lichtenberger (2009) provided a thorough review of these subtests and the literature associated with the subtests and previous incarnations of the subtests. There seemed to be no reason individuals who were blind could not complete any of the subtests in the verbal comprehension index. It should also be noted

that Kaufman and Lichtenberger (2009) reported the verbal comprehension index had the highest positive correlation with FSIQ of all the WAIS-IV indices.

The Psychological Corporation (2008) provided materials with the WAIS-IV that explained the working memory index was composed of three subtests: digit span, arithmetic, and letter-number sequencing, which was an optional subtest. The digit span subtest required participants to listen as the examiner read a series of numbers aloud and then repeat those number just as the examiner said them, first forward, then backward, and then the participant was required to properly order numbers as well as letters. Digit span was considered to be a measure of the CHC theory ability short-term memory. The arithmetic subtest required the participant to attend as the examiner read a math problem aloud and correctly solve the math problem without the use of pencil, paper, or calculator. Arithmetic was considered to mostly be a measure of the CHC theory ability short-term memory. The letter-number sequencing subtest required the participant to attend as the examiner read a string of letters and numbers aloud and then verbally repeat the letters and numbers back after putting them in order. Letter-number sequencing was thought to be tapping into the CHC theory ability short-term memory. Kaufman and Lichtenberger (2009) again provided a thorough review of these subtests and the literature associated with them and previous incarnations of the subtests, there seemed to be no reason individuals who were blind could not complete any of the subtests within the working memory index.

The Psychological Corporation (2008) provided materials with the WAIS-IV explaining the perceptual reasoning index was composed of five subtests: block design, matrix reasoning, visual puzzles, picture completion, and figure weights, but the last two

subtests were optional. The block design subtest required participants to recreate designs presented to him or her via pictures by using multicolored blocks. Block design was thought to tap into the CHC theory abilities fluid intelligence and visual processing. The matrix reasoning subtest required participants to view a series of stimulus pictures presented by the examiner and then identify how the pattern depicted by the stimuli would best be completed by selecting another picture to fit in the original. Matrix reasoning was thought to be a measure of the CHC abilities fluid intelligence and visual processing. The visual puzzles subtest required the participant to visually examine a series of pictures and mentally rotate the figures to best complete a puzzle. Visual puzzles was said to capture the CHC theory abilities fluid intelligence and visual processing. Picture completion was an optional subtest that required participants to view a picture of an object and identify what part of the picture was missing. Picture completion was thought to tap into the CHC theory abilities fluid intelligence and short-term memory. The figure weight subtest was optional, but required participants to use logic to identify the weights of figures via pictures presented to him or her by the examiner. Figure weights was thought to tap into the CHC theory abilities fluid intelligence and visual processing. Kaufman and Lichtenberger (2009) provided a thorough review of the subtests and the literature associated with them and previous incarnations of the subtests. Not one of the subtests within the perceptual reasoning index seemed to be able to be completed by individuals who were blind because of the heavy emphasis on visual perception.

The Psychological Corporation (2008) provided materials with the WAIS-IV explaining the processing speed index was composed of three subtests: symbol search,

coding, and the optional subtest of cancellation. The symbol search subtest required participants to visually scan a row of symbols to check for the presence of two separate target symbols and then indicate whether the target symbols are present via pencil and paper all while under time constraint. Symbol search was thought to tap into the CHC theory ability cognitive processing speed. The coding subtest required participants to visually scan a series of symbols and corresponding numbers. The participant must then apply the correct number to a long series of symbols missing the corresponding numbers via pencil and paper while under time constraint. Coding was thought to measure the CHC theory ability cognitive processing speed. The cancellation subtest was optional, but required participants to visually scan a large sheet full of different shapes and use a pencil to mark through all the target shapes they can within the time limit. Cancellation was thought to be tapping into the CHC theory ability cognitive processing speed. Kaufman and Lichtenberger (2009) provided a thorough review of these subtests and the literature associated with them and previous incarnations of the subtests, not one of the subtests within the processing speed index seemed to be able to be completed by individuals who were blind because of the heavy emphasis on visual perception (Flanagan & Kaufman, 2004).

WAIS-IV and Individuals Who Are Blind

Some researchers suggested administering only the verbal comprehension and working memory indices to adults who qwre blind and using those two index scores in place of a FSIQ; however, without the FSIQ generated from all four index scores a person might not be able to be diagnosed with a learning disability or attention deficit-hyperactivity disorder (Flanagan & Kaufman, 2004; The Psychological Corporation,

2008; Lichtenberger & Kaufman, 2009). Further, according to Carroll (1997) and Kaufman and Lichtenberger (2005), there was nothing in the CHC theory literature that suggested CHC theory abilities could not be applied to individuals who were blind, aside from the visual processing ability. Logic dictated that if an individual who was blind were able to perceive the stimuli of the WAIS-IV, he or she would be able to complete it, but there was not an intelligence test available that attempted to transform the WAIS-IV perceptual reasoning and processing speed indices into measures readily accessible by individuals who were blind.

There was considerable evidence to suggest that individuals who were blind could perform well on intellectual measures if the content of those measures was applicable to him or her (Kaufman & Lichtenberger, 2005; Lichtenberger & Kaufman, 2009; Spearman, 1904). More than 100 years ago, Spearman (1904) rocked the intellectual assessment world with his definition and measurement of general intelligence. He reasoned that tactile perception was one of the better ways to measure intelligence when he said "Touch is the most direct of the senses, the physiological organ being apparently of such a simple structure as to convey the stimulus of the brain in a purely mechanical manner" (p. 247). According to Kaufman and Lichtenberger (2005), Spearman's work influenced nearly every scientist in the realm of intellectual assessment from 1904 through the present and his work will likely continue to influence future generations of scientists. The only major problem with attempting to gauge intelligence based on nonvisual performance abilities was that it had rarely been done.

Haptic Intelligence Scale for Blind Adults

Almost a half century ago, Shurrager and Shurrager (1964) attempted to create an adult intelligence scale for individuals who were blind and compared it to the original WAIS. Their Haptic Intelligence Scale for Blind Adults (HISBA) was the first intellectual assessment measure designed for use in a population consisting of adult individuals who were blind. It consisted of seven individual subtests: digit symbol, object assembly, block design, plan-of-search, object completion, pattern board, and bead arithmetic. Shurrager and Shurrager conducted Pearson's correlations on all of the HISBA scales and the verbal scales from the original WAIS which revealed significant positive correlations between all of the subtests.

Shurrager and Shurrager (1964) reported the subtests of the HISBA could not be used to form any indices or overall global assessment of functioning. Their digit symbol subtest required a participant to use his or her hands to explore stimuli and based on the number of dots observed he or she was to refer back to the stimulus key and determine what number was being represented. Their object assembly subtest consisted of several different common objects disassembled and required the participant to reassemble them correctly. The block design subtest they employed consisted of four blocks with textured sides and required participants to recreate designs using those blocks. The plan-of-search subtest they used required participants to search a sheet of paper via a pencil looking for a small hole. Their object completion subtest required the participant to identify several common objects that had one key piece missing from them. The pattern board subtest they used consisted of a piece of peg board that could be formatted to form different designs which the participant had to identify. Finally, their bead arithmetic subtest

consisted of an abacus the participant would use to solve math problems the examiner presented to him or her orally.

Cognitive Test for the Blind

Shurrager and Shurrager's (1964) HISBA showed considerable promise as a measure of intellectual ability for individuals who were blind, but it was never updated or revised and was no longer available for use. However, in 2002 Nelson, Dial, and Joyce conducted research attempting to validate the Cognitive Test for the Blind (CTB). They said the CTB consisted of 10 subtests, five falling under the realm of verbal (auditory analysis and sound repetition, immediate digit recall, language comprehension and memory, letter-number learning, and vocabulary) and five falling into the realm of performance (haptic category learning, haptic category memory, haptic memory recognition, spatial pattern recall, and spatial analysis). The CTB also was reported to yield a six-factor structure that included: conceptual, learning, verbal memory, nonverbal memory, language, and spatial ability. However, Nelson et al. (2002) did not provide any specific information regarding the details of what each factor was supposedly measuring or which subtests went into each factor.

Though the factors of the CTB were never discussed in detail, Nelson et al. (2002) did provide a brief description of each of the 10 subtests. They reported the auditory analysis and sound repetition subtest required participants to listen to pseudo-words and repeat them to the examiner quickly. Immediate digit recall required the participant to verbally recall a string of numbers presented orally by the examiner. Language comprehension and memory asked the participants to listen to a story told by the examiner and then recall specific details. Letter-number learning required the participant

to recall letter and number pairs presented orally by the examiner. The vocabulary subtest required the participant to define words orally. The haptic category learning subtest asked the participant to examine an object and tell the examiner what number it represented. Haptic category memory asked the participant to select familiar objects while also presented with distractor objects. Haptic memory recognition asked the participant to identify different patterns based on textures presented on a series of tiles. Spatial pattern recall required that the participant recreate patterns based on a series of textured tiles. Finally, their spatial analysis subtest required participants to match shapes and patterns based on different objects presented by the examiner.

Towards a New Nonvisual Measure of Cognitive Ability

Neither Shurrager and Shurrager's (1964) HISBA nor Nelson et al.'s (2002) CTB conceptualized intelligence in terms of the CHC theory of abilities. One could speculate on the nature of each of the HISBA and CTB subtests in terms of CHC theory abilities, but such an endeavor would be pointless because neither the HISBA nor CTB was compared to the current gold standard of adult intellectual assessments: the Wechsler adult scales. This was a considerable gap in the realm of scientific assessment of adult intelligence, but it presented a great opportunity for research.

Roberts, Stankov, Pallier, and Dolph (1997) recognized this gap and began to explore the possibility of a new CHC-like factor: tactile-kinesthetic performance. They defined tactile-kinesthetic performance as an individual's ability to manipulate objects quickly and accurately in order to successfully complete a task. In addition, they reported that visual processing ability, working memory, fluid intelligence, and likely overall *g* were significantly correlated with tactile-kinesthetic ability. However, they did not make

use of a formal assessment of intelligence to make further comparisons and explore potential relationships to gold standard measures. In addition, the measures employed by the researchers were comprised of a large visual component and the battery they employed likely could not be completed by an individual who was blind.

Several researchers have made use of the tactile-kinesthetic ability factor and even compared it to short-form measures of intelligence (e.g., Li, Jordanova, & Lindenberger, 1998; Stankov, Seizova-Cajic, & Roberts, 2001). Both researchers compared measures involving tactile discrimination and correlated those measures with tests designed to capture fluid intelligence. The sensory discrimination tasks involved detection of texture changes and differing shapes. They reported weak to moderate positive correlations between all measures. However, in each study the participants were fully sighted and a gold standard intelligence measure was not used.

Duncan, Weidl, Prickett, Vernon, and Hollingsworth-Hodges (1989) modified existing measures of intellectual functioning for use by individuals who were blind, but did not find encouraging results. They attempted to adapt the Test of Nonverbal Intelligence (TONI) by changing items via adding rough textures and raised lines on numerous items. They experienced harsh criticism from participants and reviewers. The researchers were only able to gather 11 individuals who were blind to participate and only 9 of the 11 completed the measure. The administration time of their measure was criticized for requiring roughly ninety-minutes and quickly fatiguing participants. In addition, the measure was unable to produce significant correlations with the WAIS or WAIS-R. Duncan et al. (1989) reported that the tactile TONI was "not a satisfactory performance IQ test for blind persons" (p. 511). Despite the numerous problems Duncan

et al. experienced, at least their measure was subjected to real world clinical research, which cannot be said of all measures.

Taylor and Ward (1990) set out with the lofty goal of furthering the scientific literature supporting the Tactile Progressive Matrices (TPM) and the use of the measure with individuals who were blind. However, they quickly encountered a problem: no one had a copy of it, or even knew where to find one. Taylor and Ward conducted a thorough review of the literature and found the TPM cited by numerous other researchers since the late 1960s. However, after many phone calls and letters, Taylor and Ward discovered that these researchers had been improperly citing secondary sources and had never actually seen the TPM. They discovered that the truth was the TPM had been used once, by the first author as a dissertation project. Further, the first author no longer had a copy of the TPM. It was later revealed that the dissertation chair reported he might have a copy of the TPM, but he was not sure. No copy of the TPM ever surfaced.

There was clearly a need for a well-developed, well-normed instrument capable of capturing the intellectual functioning of individuals who were blind. Further, it would be preferable for this instrument to be able to be used in conjunction with the current gold standard measure of intelligence, i.e., the WAIS-IV (Kaufman & Lichtenberger, 2005; Lichtenberger & Kaufman, 2009; The Psychological Corporation, 2008). This instrument would enable psychologists to accurately measure and document an individual who was blind's FSIQ and provide aid to persons suffering from learning disabilities and attention-deficit hyperactivity disorder via different state and federal government programs. However, speculating about the need for such a measure and actually creating such a measure were two very different things. The creation of an instrument capable of

capturing the cognitive abilities of individuals who were blind would likely require years of work and an extremely large normative sample. Though the process of instrument development was long and arduous, it had to begin somewhere.

Tactile Assessment of Performance

There was not an adult intelligence measure available for individuals who were blind that was based on the CHC theory of intellectual abilities, which were considered to be the gold standard in intellectual assessment. The proposed research sought to rectify that situation through the introduction of five new nonvisual, performance-based subtests to be used in place of the perceptual reasoning and processing speed subtests of the WAIS-IV. Specifically, the new subtests were designed to measure one of two abilities in the CHC theory. Tactile tile design, tactile block configurations, and tactile figure-ground identification were designed to measure fluid intelligence. Tactile figure exploration and tactile matching were designed to measure cognitive processing speed. The overall battery of subtests to be used in the measurement of the intellectual functioning of individuals who were blind was referred to as the Tactile Assessment of Performance (TAP).

Tactile Tile Design

The first subtest of the TAP was tactile tile design. Tactile tile design was partially based on the block design subtest of the WAIS-IV, published by The Psychological Corporation (2008). Lichtenberger and Kaufman (2009) reported the block design subtest had been used in various measures of intelligence for decades and was considered to be one of the better subtests on the WAIS-IV for determining overall intelligence, detecting potential neurological functioning problems, detecting problems

related to attention and concentration functioning, and detecting problems related to anxiety. They said the block design subtest had consistently produced excellent validity and reliability numbers, and in the most current edition of the WAIS the block design subtest demonstrated sound split-half reliability and test-retest reliability of .87 and .80, respectively. Further, Kaufman and Lichtenberger (2005) determined that the block design subtest had a strong, significant loading on overall *g* of .72.

The Psychological Corporation (2008) asserted that the basic premise of the block design subtest required the participant to use multicolored blocks to create designs presented to him or her pictorially. Further, they reported the block design subtest was timed and if the participant was able to complete an item on the block design subtest fast enough, the participant would receive bonus points. However, if the participant did not complete the item fast enough, he or she would go over the allotted time limit on the item and receive no points for his or her efforts. In addition, if the participant did not reproduce the design correctly, he or she would receive no points for his or her efforts. It was the duty of the examiner to teach the participant the basic rules of the block design task and standardized instructions were provided to be read aloud. If the participant experienced difficulty correctly completing the first two items of the block design subtest, the examiner was instructed to perform a reversal rule. The reversal rule dictated that the examiner halt the participant's forward progress through the block design subtest and reverses the progression. As the participant progressed through the block design subtest the items became more difficult. When the reversal rule was applied the examiner administered a special set of items designed to be very easy and aid the participant in understanding the basic concept of the block design task. When the participant had

successfully completed two items in a row, the examiner stopped applying the reversal rule and allowed the participant to continue his or her progression through the block design subtest. If the participant experienced further difficulty in the block design subtest, the examiner might be required to apply the discontinue rule. The discontinue rule required the examiner to observe the performance of the participant and should the participant receive a score of zero on two items in a row, the examiner was required to end the administration of the block design subtest and move on to the next subtest of the battery.

The Psychological Corporation (2008) and Lichtenberger and Kaufman (2009) wrote extensively about the role of the examiner. Obviously, the examiner played an important role in the administration of this subtest and graduate level training was required to administer and score the block design subtest as well as all other WAIS-IV subtests and TAP subtests. Further, the role of the examiner was fluid and the examiner adapted to each participant. Some participants might experience difficulty understanding the standardized instructions and the examiner was prepared to answer questions. In addition, it was important for the examiner to remember that he or she was an advocate for the participant and was there to aid the participant in performing as well as possible. The examiner was also often considered to be the participant's rescuer. In other words, if the participant was struggling with one particular item on the block design task, the examiner was to provide him or her with an opportunity to move on to the next item. According to The Psychological Corporation (2008) and Lichtenberger and Kaufman (2009), prolonged exposure to the same item might frustrate or fatigue the participant. The examiner played the same role in tactile tile design.

Tactile tile design was similar to the block design subtest put forth by The Psychological Corporation (2008) in that participants were required to examine a design and recreate it, but tactile tile design was specifically designed to be completed by individuals who were blind. The initial incarnation of the tactile tile design subtest used one inch square blocks with sandpaper covering some sides and partially covering other sides. It required participants to examine a four-inch by four-inch square design consisting of smooth and textured surfaces and recreate the design via the blocks. However, the researcher was confronted by numerous problems and concerns regarding the size of the blocks and designs. Throughout the creation of tactile tile design the researcher consulted with an expert in the area of blindness who was also an individual who was blind. Based on this consultation with the expert, the researcher modified the task a great deal. Tiles were deemed more appropriate than the small blocks, the design to be recreated by participants was also altered to better fit with the use of tiles, and the texture differences were also adjusted significantly.

The current incarnation of tactile tile design was administered in a manner similar to the block design subtest. Tactile tile design made use of standardized instructions, a reversal rule, and a discontinue rule; however, for the purposes of the current research all items were administered to all participants who were blind so the item difficulty could be rated empirically. Further, it was a timed task and participants might earn bonus points if they completed the tactile tile design item within a specified time limit. In addition, the role of the examiner was also that of an advocate for the participant and part of the examiner's duty was to help the participant understand the task before him or her, apply

the reversal and discontinue rules as appropriate, and rescue the participant when appropriate.

As previously mentioned, The Psychological Corporation (2008) and Lichtenberger and Kaufman (2009) reported the block design subtest was said to be a measure of fluid intelligence and visual processing. The researcher expected the tactile tile design subtest to be a sound measure of fluid intelligence and cognitive processing speed, but investigated this expectation via statistical means. However, this issue was discussed in greater detail in Chapter Three.

Tactile Figure Exploration

The second subtest of the TAP was tactile figure exploration. Tactile figure exploration was based on the symbol search subtest that had been used as a part of several different Wechsler tests for decades (Kaufman & Lichtenberger, 2005; The Psychological Corporation, 2008). Lichtenberger and Kaufman (2009) reported the symbol search subtest was considered to be a sound subtest on the WAIS-IV for determining overall intelligence, detecting potential neurological functioning problems, detecting problems related to attention and concentration functioning, and detecting problems related to anxiety. They said the symbol search subtest had consistently produced good validity and reliability numbers, and in the most current edition of the WAIS the symbol search subtest demonstrated sound split-half reliability and test-retest reliability of .81 for each of the reliability indices. Further, Lichtenberger and Kaufman determined that the symbol search subtest had a strong, significant loading on overall *g* of .70.

The Psychological Corporation (2008) reported the symbol search task required participants to rapidly scan a target area and a search area to correctly indicate whether either of the two target symbols were present in the search area via marking a line through either yes or no on a response form. The WAIS-IV incarnation of the symbol search task allowed the participant two-minutes to complete as many items as possible and speed and accuracy were encouraged via the standardized instructions. Unlike block design, there was no reversal or discontinue rule. The participant simply responded to items until the examiner told the participant to stop. Participants received one point per correct response on each item of the symbol search task. Participants were not penalized for items they did not complete, perhaps because of the time constraint. However, any item the participant completed incorrectly (i.e., indicating a target symbol is present when it is not actually present) were subtracted from the total number of correct items.

According to The Psychological Corporation (2008), the examiner's role in symbol search was less significant than block design because there were no discontinue rules or reversal rules with which to be concerned. The examiner was required to follow the standardized instructions and keep accurate time records. Aside from those responsibilities, the symbol search task was rather quick and easy to administer.

Much like tactile tile design, tactile figure exploration had undergone numerous revisions since its original incarnation. The original tactile figure exploration items were much larger than the WAIS-IV symbol search items, but could still fit on a standard sheet of notebook paper. The basic premise of tactile figure exploration required participants to explore a target and search area consisting of different figures and different textures. Similar to the symbol search task, participants completing tactile figure exploration were

required to verbally indicate yes or no whether the target figure was within the search area. After consulting with an expert in the field of individuals who were blind, the tactile figure exploration items were made much larger than the original design and the texture differences were adjusted.

The current incarnation of tactile figure exploration was administered and scored in a manner similar to the WAIS-IV symbol search subtest. It was a timed task and the participant earned points based on the number of items he or she responded to correctly and the number of items he or she responded to incorrectly. The role of the examiner was to be that of an advocate for the participant and part of the examiner's duty was to help the participant understand the task before him or her and apply appropriate time constraints and scoring procedures.

As previously mentioned, The Psychological Corporation (2008) reported the symbol search subtest was said to be a measure of cognitive processing speed. It was expected that the tactile figure exploration subtest would also be a sound measure of cognitive processing speed and this was investigated via statistical means. However, this issue was discussed in greater detail in Chapter Three.

Tactile Matching

The third subtest of the TAP was the tactile matching subtest. Tactile matching was based on the cancellation subtest that The Psychological Corporation (2008) had been using on numerous Wechsler instruments for decades. Lichtenberger and Kaufman (2009) indicated the cancellation subtest was considered to be a sound subtest on the WAIS-IV for determining overall intelligence, detecting potential issues related to impulsivity, detecting problems related to attention and concentration functioning, and

detecting problems related to planning. They asserted the cancellation subtest had consistently produced sound validity and reliability numbers, and in the most current edition of the WAIS the cancellation subtest demonstrated good split-half reliability and test-retest reliability of .78 and .78, respectively. Groth-Marnat (2009) reported that, traditionally, the cancellation subtest had produced a significant, but low correlation with overall *g*; however, according to Kaufman and Lichtenberger (2005) it had produced strong correlations when compared to the overall Processing Speed Index scores.

The Psychological Corporation's (2008) cancellation task required participants to rapidly scan a large search area and correctly identify target figures via marking through them with a pencil. The WAIS-IV incarnation of the cancellation task allowed the participant two-minutes to complete as many items as possible and speed and accuracy were encouraged via the standardized instructions. There was no reversal or discontinue rule. The participant simply responded to items until the examiner told the participant to stop. Participants received one point per correct response on each item of the cancellation task. Participants were not penalized for items they did not complete, perhaps due to the time constraint. However, any items the participant completed incorrectly (i.e., indicating a target figure is present when it was not actually present) were subtracted from the total number of correct items.

The examiner's role in cancellation was rather hands off because there were no discontinue rules or reversal rules with which to be concerned. The examiner was required to follow the standardized instructions and keep accurate time records. Aside from those responsibilities, The Psychological Corporation (2008) indicated the cancellation task was rather quick and easy to administer.

Much like the other TAP subtests, tactile matching had undergone numerous revisions since its original incarnation. The original tactile matching items were slightly larger than the WAIS-IV cancellation items, but could still fit on a standard sheet of paper. The basic premise of tactile matching required participants to explore a search area consisting of different shapes and different textures. Similar to the cancellation task, participants completing tactile matching were required to place a poker chip over the target shape. After consulting with an expert in the field of individuals who were blind, the tactile matching items were made much larger than the original design and the texture differences were adjusted.

The current incarnation of tactile matching was administered and scored in a manner similar to the cancellation subtest. It was a timed task and the participant earned points based on the number of items he or she responded to correctly and the number of items he or she responded to incorrectly. The role of the examiner was to be that of an advocate for the participant and part of the examiner's duty was to help the participant understand the task before him or her and apply appropriate time constraints and scoring procedures.

As previously mentioned, The Psychological Corporation (2008) reported the cancellation subtest was a measure of cognitive processing speed. The researcher for the current study expected the tactile matching subtest would also be a sound measure of cognitive processing speed and investigated this expectation via statistical means. However, this issue was discussed in greater detail in Chapter Three.

Tactile Figure-Ground Identification

The fourth subtest of the TAP was tactile figure-ground identification. The tactile figure-ground identification subtest was based on the digit symbol subtest of Shurrager and Shurrager's (1964) HISBA and Spearman's (1904) work regarding sensory discrimination as a measure of intelligence. The tactile figure-ground identification subtest was designed to be a measure of fluid intelligence, cognitive processing speed, and short-term memory.

The tactile figure-ground identification task required participants to distinguish potential differences in pairs of textured paper (stimulus items) presented to them by the examiner. Specifically, the participant was given a nine-by-eleven-inch sheet of paper. The paper had designs on it ranging from different geometric shapes to curved lines and other patterns. The participant was allowed ten-seconds to examine the first sheet presented to him or her. After ten-seconds, the examiner politely removed the first stimulus item (sheet of paper) and presented the second stimulus item (another sheet of paper). The second stimulus item might have contained an exact duplicate of the textured shape or design as the first stimulus item, or a different design. The participant was asked to identify whether the second stimulus item was the same as the first stimulus item and was allowed twenty-seconds with which to make a decision and verbally inform the examiner of that decision.

After the examiner read the standardized instructions aloud to the participant, the participant was administered two trial item pairs to ensure the participant understood what was required to successfully complete the task. Should the participant fail to successfully complete either of the two trial items, the examiner applied a reversal rule

and administered less complex item pairs until the participant completed two consecutive items successfully. The participant continued completing items on the subtest until the participant produced three incorrect responses consecutively. At that point, the examiner applied a discontinue rule and moved on to the next TAP subtest; however, for the purposes of the current research all items were administered to all participants who were blind so the item difficulty might be rated empirically. In addition, if a participant was unable to provide a correct response to an item after thirty-seconds, the examiner would rescue the participant and encourage the participant to move on to the next item pair or move on to the next subtest, depending on which was appropriate.

The examiner's role in the tactile figure-ground identification subtest was rather hands on when compared to the previous two TAP subtests. The role of the examiner was fluid and the examiner adapted to each participant. The examiner was prepared to answer any questions the participant might have and adopted the role of the participant's advocate, helping the participant produce the best score possible. The examiner was required to keep accurate time, present the stimulus items in an organized manner, and keep track of the participant's responses so they could be correctly scored.

Much like the other TAP subtests, tactile figure-ground identification had undergone a few revisions since its original incarnation. After numerous consultations with an expert, the tactile figure-ground identification items were re-sized and the figures and textures modified as well. The current incarnation of the tactile figure-ground identification subtest relied on scoring procedures similar to The Psychological Corporation's (2008) Wechsler instruments. Specifically, participants received one point per correct response within the time limit, zero points for incorrect responses, and zero

points for correct responses delivered outside of the time limit. As previously stated, the tactile figure-ground identification subtest was expected to be a measure of primarily fluid intelligence, but might also tap into cognitive processing abilities. The researcher investigated this possibility via statistical methods, which was discussed further in Chapter Three.

Tactile Block Configurations

The fifth and final subtest of the TAP was tactile block configurations. The tactile block configurations subtest was based on the object assembly subtest of Shurrager and Shurrager's (1964) HISBA and Spearman's (1904) work regarding sensory discrimination as a measure of intelligence. The tactile block configurations subtest was designed to be a measure of fluid intelligence, cognitive processing speed, and short-term memory.

The tactile block configurations task required participants to distinguish potential differences in pairs of three-dimensional block configurations (stimulus items) presented by the examiner. Specifically, the participant was given a three dimensional block configuration. The block configurations were a variety of geometric shapes and patterns. The participant was allowed ten-seconds to examine the first block configuration presented to him or her. After ten-seconds, the examiner politely removed the first stimulus item (block configuration) and presented the second stimulus item (another block configuration). The second stimulus item might be an exact duplicate of the first stimulus item, or it could be a different configuration. The participant was asked to identify whether the second stimulus item was the same as the first stimulus item and was allowed twenty-seconds with which to decide and verbally inform the examiner.

The examiner was tasked with reading the standardized instructions aloud to the participant; the participant was administered two trial item pairs to ensure the participant understood what was required to successfully complete the task. Should the participant fail to successfully complete either of the two trial items, the examiner applied a reversal rule and administered less complex item pairs until the participant completed two consecutive items successfully. The participant would continue completing items on the subtest until the participant produced three incorrect responses consecutively. At that point the examiner would apply a discontinue rule and thank the participant for his or her time and participation in the research project; however, for the purposes of the current research all items were administered to all participants who were blind so the item difficulty might be rated empirically. In addition, if a participant was unable to provide a correct response to an item after thirty-seconds, the examiner rescued the participant and encourage the participant to move on to the next item pair or end the testing procedure, depending on which was appropriate.

The examiner's role in the tactile block configurations subtest was hands on, much like the previous TAP subtest. The role of the examiner remained fluid and the examiner adapted to each participant. The examiner was prepared to answer any questions the participant might have and adopted the role of the participant's advocate, helping the participant produce the best score possible. The examiner was required to keep accurate time, present the stimulus items in an organized manner, and keep track of the participant's responses so they might be correctly scored.

Much like the other TAP subtests, tactile block configurations had undergone a few revisions since its original incarnation. After numerous consultations with an expert,

the tactile block configurations items were re-sized and the figures and adhesives modified as well. The current incarnation of the tactile block configurations subtest relied on scoring procedures similar to The Psychological Corporation's (2008) Wechsler instruments. Specifically, participants received one point per correct response within the time limit, zero points for incorrect responses, and zero points for correct responses delivered outside of the time limit. As previously stated, the tactile block configurations subtest was expected to be a measure of fluid intelligence and cognitive processing skills. The researcher investigated this possibility via statistical methods, which was discussed further in Chapter Three.

Current Study

The current study undertook the first step in a long journey toward developing a performance-based intellectual assessment designed specifically for individuals who were blind. After a thorough review of the scientific literature surrounding intellectual assessment and the CHC three stratum theory of intelligence, there seemed to be no reason why this theory could not be applied to individuals who were blind, provided the individuals who were blind were able to perceive and complete the tasks designed to capture CHC abilities. The researcher administered the WAIS-IV and TAP to thirty-two participants who were sighted and administered the Verbal Comprehension Index subtests and Working Memory Index subtests in addition to the TAP subtests to thirty-two individuals who were blind. Participants were recruited from a mid-size Southern university and through a training center for individuals who were blind.

The first hypothesis (H_1) was that there would be a positive correlation among the Perceptual Reasoning Index and Processing Speed Index of the WAIS-IV and the TAP

subtests when completed by individuals who were sighted. The subtests of the TAP were based on the CHC abilities associated with Perceptual Reasoning and Processing Speed, but without the visual component. Given the available information supporting the use of the Perceptual Reasoning Index and Processing Speed Index as sound measures of CHC abilities, it was logical to assume that the TAP subtests based on the subtests that comprise the indices would be capturing at least a portion of the same construct (e.g., Lichtenberger & Kaufman, 2009; Roberts, et al., 1997; The Psychological Corporation, 2008).

The second hypothesis (H_2) was that there would be positive correlations among the WAIS-IV subtests visual puzzles, matrix reasoning, block design, coding, and symbol search and the TAP subtests in participants who were sighted. Following the logic of H_1, the subtests of the performance-based indices of the WAIS-IV were believed to measure the CHC abilities cognitive processing speed, visual processing, and fluid intelligence (e.g., Lichtenberger & Kaufman, 2009; The Psychological Corporation, 2008). The subtests of the TAP were designed to capture the cognitive processing speed and fluid intelligence abilities of participants in a similar manner as the WAIS-IV subtests.

The third hypothesis (H_3) was that scores on the WAIS-IV Verbal Comprehension Index and Working Memory Index would correlate positively with scores on TAP subtests when completed by individuals who were blind. This hypothesis was based heavily on the research of Spearman (1904) and the *g* factor. The Verbal Comprehension Index and Working Memory Index were well-validated, established measures of *g* (e.g., Lichtenberger & Kaufman, 2009; Roberts et al., 1997; The Psychological Corporation, 2008). The subtests of the TAP were based on the work of Spearman (1904) and his work

regarding sensory discrimination as an aspect of overall *g*. The subtests of the TAP were not expected to capture the same CHC abilities as the Verbal Comprehension and Working Memory Indices, but the TAP subtests were expected to capture some of the overall ability (i.e., *g*).

The fourth hypothesis (H_4) was that scores on the WAIS-IV similarities, vocabulary, information, arithmetic, and digit span would correlate positively with scores on TAP subtests when completed by individuals who were blind. Similar to the logic of H_3, it was reasonable to assume that because the Verbal Comprehension and Working Memory Indices were capturing at least part of the construct of *g* that the subtests which comprise those indices would also be capturing part of *g* (e.g., Lichtenberger & Kaufman, 2009; Spearman, 1904; The Psychological Corporation, 2008).

The fifth hypothesis (H_5) was that scores on measures of conscientiousness and achievement striving would not correlate with any TAP subtests, but participant GPA would. Previous research suggested these relationships existed in correlations among intelligence and GPA, but not conscientiousness and achievement striving (e.g., Furnham, Chamorro-Premuzic, & McDougall, 2003; Laidra, Pullmann, & Allik, 2007; Moutafi, Furnham, & Paltiel, 2004). Given that the TAP was expected to correlate positively with the WAIS-IV, it was expected that the TAP would produce similar correlations in the areas of GPA, but not conscientiousness and need for achievement.

CHAPTER TWO

METHOD

Design

The current research was mostly correlational in nature. Pearson's r was utilized to investigate the relationship among all subtests of the TAP and WAIS-IV and index scores of the WAIS-IV across the group of participants who were blind and participants who were sighted. The administration of the TAP and WAIS-IV was counterbalanced to investigate the possibility of an effect of order. The multitrait-multimethod matrix (MTMM) first conceptualized by Campbell and Fiske (1959) was utilized for the current research.

Campbell and Fiske (1959) reported the MTMM was a technique employed to examine convergent and divergent validity of measures, investigate the influence of different methods of assessing those measures, and build overall construct validity. The evaluation of convergent validity was conducted by investigating the relationships among TAP subtests as well as the similarities, vocabulary, information, arithmetic, and digit span subtests of the WAIS-IV, the Barona estimate of intelligence, and participant's self-reported GPA. The Barona estimate of intelligence was developed by Barona, Reynolds, and Chastain (1984) and was based on demographic factors such as age, gender, race,

education, and occupation, which have demonstrated strong, positive correlations with overall intellectual functioning. Laidra, Pullmann, and Allik, (2007) indicated positive relationships between GPA and intelligence. The evaluation of divergent validity was conducted by investigating the relationships between conscientiousness and achievement striving as measured by the Costa and McCrae's (1992) Revised NEO Personality Inventory (NEO-PI-R). Moutafi, Furnham, and Paltiel (2004) reported there might be a negative relationship between conscientiousness and verbal intelligence, but performance intelligence had not demonstrated a significant relationship with conscientiousness. Furnham, Chamorro-Premuzic, and McDougall (2003) reported that achievement striving might not be positively correlated with verbal intellectual abilities and there should not be a correlation between achievement striving and performance-based intelligence measures. Multiple methods of assessment of traits were employed in the current research. The Barona estimate of intelligence was based on demographic information. The TAP and WAIS-IV required individual administration and were performance-based measures. The conscientiousness and achievement striving traits were measured via Costa and McCrae's (1992) achievement striving index and conscientiousness index and GPA were measured via participant self-report.

All participants who were blind completed all items of the TAP for the purpose of empirically determining the difficulty level of items. The items and subtests of the TAP were scored and the percentage of correct responses per item calculated. The difficulty ranking for future use of the TAP will be based on the item difficulty ratings.

Participants

Participants who were blind were asked to participate after the primary researcher conducted a presentation on the current research at a training center for individuals who were blind. Participants who were blind were required to have completed or be currently enrolled in nonvisual training. A total of thirty-two participants who were blind completed the current research project. That number was low for an entire normative sample, but the current research was viewed as a pilot study attempting to address any unforeseen challenges and assess the initial validity of the new measures. Participants who were blind were defined as individuals who were legally blind. Though persons might be classified as legally blind, the persons might still possess some residual visual capability. To eliminate this potential confound, all participants who were legally blind were required to wear blindfolds during the administration of the TAP. Participants who were blind completed the Verbal Comprehension and Working Memory indices of the WAIS-IV as well as the TAP subtests. Participation required approximately two hours and participants were compensated via twenty dollars cash. Participants who were blind were screened by asking individuals who had experienced a traumatic brain injury or problems with diabetes and/or neuropathy to not participate.

Participants who were sighted were gathered from undergraduate psychology courses at a mid-sized Southern university. A total of thirty-two participants who were sighted completed the current research. These participants completed the entire WAIS-IV and the TAP subtests. Participants who were sighted completed the TAP subtests while wearing a blindfold. Participation required approximately two hours and participants were compensated via twenty dollars cash.

Measures

Costa and McCrae's (1992) achievement striving index of the NEO-PI-R was used as part of the MTMM for the current research. They reported the achievement striving index had been shown to have sound internal consistency with a Cronbach's α of .78. It was a ten-item survey set on a five-point Likert type scale with one indicating *not at all like me* and five indicating *very much like me*. Five of the ten items were positively worded.

Costa and McCrae's (1992) conscientiousness index of the NEO-PI-R was used as part of the MTMM for the current research. They reported the conscientiousness index had been shown to possess sound internal consistency with a Cronbach's α of .81. It was a ten-item survey based on a five-point Likert type scale with one as *not at all like me* and five as *very much like me*. In addition, five of the ten items were positively worded.

Given the dearth of literature regarding the use of the achievement striving and conscientiousness measures in participants who were blind, the researcher believed it best to explore the reliability of the measures. Cronbach's α revealed internal consistency figures of .77 for the achievement striving index and .76 for the conscientiousness index, both of which indicated acceptable levels of internal consistency according to Nunnally and Bernstein (1994). These were similar to those produced by participants who were sighted, .81 for achievement striving and .74 for conscientiousness. The combined participants groups produced internal consistency levels of .78 for the achievement striving index and .76 for the conscientiousness index. Overall, the internal consistency levels for the use of the achievement striving and conscientiousness measures were acceptable when applying the guidelines set forth by Nunnally and Bernstein.

To further investigate the use of the achievement striving and conscientiousness measures in a sample of individuals who were blind, a secondary set of sample data were collected. The secondary sample investigation made use of Cronbach's α, which revealed internal consistency figures of .82 for the achievement striving index (N = 185) and .86 for the conscientiousness index (N = 188). These reliability figures supported the use of the achievement striving and conscientiousness measures in a sample of individuals who were blind.

In addition, the initial sample of individuals who were blind and the secondary sample of individuals who were blind were compared to look for potential differences between the two samples based on achievement striving and conscientiousness. Investigation revealed no difference between the initial and secondary sample in regard to achievement striving ($t(215) = .148$, $p = .882$; Cohen's $d = 0.020$; $M = 41.97$, $SD = 4.25$ and $M = 41.83$, $SD = 4.88$, respectively). There was no difference between the initial and secondary sample in regards to conscientiousness ($t(218) = -1.080$, $p = .281$; Cohen's $d = 0.146$; $M = 39.28$, $SD = 4.52$ and $M = 40.29$, $SD = 4.96$, respectively).

Barona et al.'s (1984) Barona estimate of intelligence was based on demographic information. They indicated factors including age, gender, race, education level, occupation, and geographic region in which the participant originated were entered into a mathematical formula that produced an estimate of participant full scale intellectual functioning. Their research indicated a strong, positive relationship between the Barona and the FSIQ produced by the early incarnations of the Wechsler intelligence scales.

The WAIS-IV was one of the gold standard tests for adult intellectual assessment, according to Lichtenberger and Kaufman (2009). They reported that for many years the

Wechsler series of intelligence tests had been some of the most reliable and valid measures available to scientists and practitioners. The WAIS-IV had been available for a relatively short amount of time, so long-term reliability and validity numbers were not yet available; however, The Psychological Corporation (2008) reported the subtests of the WAIS-IV already demonstrated good internal consistency with stability coefficients ranging from .71 to .90 for all subtests.

The Tactile Assessment of Performance (TAP) consisted of five subtests: tactile tile design, tactile figure exploration, tactile matching, tactile figure-ground identification, and tactile block configurations. Prior to administration of the TAP, the examiner read the following to the participant: "Today I'm going to ask you to do a number of different things and solve a few different problems. Some of them will be easy and some of them will be hard. This measure is designed so that no one gets all items correct. Please let me know if you have any questions."

The tactile tile design task was the first subtest of the TAP and consists of fourteen different items with two trial items and two items for reversal rule use. Each of the tiles was a four-inch by four-inch square that was one-quarter inch wide. There were nine tiles in total. Five of the tiles were completely covered in two-hundred-and-twenty grit sandpaper on one side and half covered on the other side. Four of the tiles were completely smooth on one side and half covered in two-hundred-and-twenty grit sandpaper on the other side. The designs to be reconstructed were the same size as the assembled tiles (please see appendix A). Prior to administration the tactile tile design subtest, the examiner delivered the following instructions: "I'd like you to examine these tiles. Some of them are half smooth and the other side completely rough. Others are half

smooth and the other side completely smooth. Today we're going to use these tiles to recreate some designs."

The tactile figure exploration task was the second subtest of the TAP and consisted of twenty-one different items with an additional three trial items. The items were presented to the participant three at a time on two-foot by eighteen-inch sheets of poster board. The poster board was divided into two sections. The section on the left contained the two target figures. The section on the right contained the five search area figures (please see appendix B). The participant was allowed two-minutes to complete as many items as possible. After the two-minute time limit had expired, the examiner continued to note the progress of individuals who were blind every minute until the subtest was completed. This was done for normatization purposes. Prior to the administration of the task, the examiner delivered the following instructions: "Now for something completely different. I'd like you to examine the item in front of you. On your left is the target area and on your right is the search area. I'd like you to examine the target area as quickly and as accurately as possible, and then examine the search area. If either of the two figures in the target area are in the search area, please say 'yes.' If neither of the figures in the target area are in the search area, please say 'no.' I will record your answers, so move as quickly as you can." After completing the five practice trials, the examiner said: "Now when I say 'go' you will have two-minutes to complete as many items as possible. Ready? Go."

The tactile matching task was the third subtest on the TAP. The tactile matching task was presented on a two-and-a-half foot by one-and-a-half foot sheet of poster board. The board contained ninety-six different shapes. Of those ninety-six shapes, twenty of

them were the target shape for the first trial, a triangle, and twenty of them were the target shape for the second trial, a rectangle. Each shape was approximately one-and-a-half square inches in size. There was also a one-foot by one-foot practice sheet of poster board containing twenty shapes, six target shapes, triangles. The participant was asked to respond by placing a fourteen-gram, clay poker chip over the shape when he or she believed he or she had correctly identified a target shape and the examiner later recorded whether the participant was correct (please see appendix E). For normative purposes, a total of five-minutes was allotted for the participant to complete this task. However, after two-minutes the examiner asked the participant to begin using a different colored chip, then after three-minutes another color change, after four-minutes another color change, and at five-minutes the task ended. Prior to administration, the examiner read the following instructions aloud: "I'd like you to examine the sheet of paper in front of you. In this task, I'd like you to search this sheet of paper and find the triangles. When you believe you have found a triangle, place a poker chip on top of it and move on. Now, let's practice." After the practice items had been completed, the examiner said: "Now you will complete the real task. Please work as quickly and accurately as possible. Ready? Go." After the completion of the first trial, the examiner said: "Now I'd like you to search this sheet of paper and find the rectangles. When you believe you have found a rectangle, place a poke chip on top of it and move on. Please work as quickly and accurately as possible. Ready? Go."

The tactile figure-ground identification task was the fourth subtest of the TAP. There were twelve tactile figure-ground identification item pairs with an additional two practice item pairs and two reversal item pairs. The item pairs were presented on nine-by-

eleven inch sheets of poster board. Each item pair was a partially smooth surface and partially rough surface, consisting of two-hundred-and-twenty grit sandpaper. Each item pair contained a design, but on some items pairs the designs were slightly different (please see appendix C). The participant was tasked with determining whether the pairs were identical or different. The participant was presented with the first half of the item pair for ten-seconds. Afterward, the first half of the item pair was removed and the participant was presented with the second half of the item pair and allowed twenty-seconds to indicate whether it was the same or different. Prior to the administration of the task, the examiner read: "Now I'm going to ask you to examine some designs and tell me if they are the same or different. You will have ten-seconds to examine the first design and then I will ask for it back. I will then present you with the second design and ask if it is the same or different. Please let me know as soon as you have determined whether the designs are the same." After these instructions were read aloud, the examiner presented the trial items.

The fifth and final subtest of the TAP was tactile block configurations. There were fifteen item pairs on the tactile block configuration subtest with an additional two trial item pairs and three reversal rule item pairs. The item pairs of the tactile block configurations subtest were composed of differing combinations of one-by-one inch square blocks, .three-quarter-by-three-quarter inch square blocks, and one-half-by-one-half inch square blocks (please see appendix D). Similar to the tactile figure-ground identification task, participants were asked to determine whether there was a difference between item pairs. The participant was presented with the first half of the item pair for ten-seconds. Afterward, the first half of the item pair was removed and the participant

was presented with the second half of the item pair and allowed twenty-seconds to indicate whether it was the same or different. Prior to the administration of the subtest, the examiner read the following aloud: "On to our next task. Now I will ask you to examine some block configurations and tell me if they are the same or different. You will have ten-seconds to examine the first block configuration and then I will ask for it back. I will then present you with the second block configuration and ask if it is the same or different. Please let me know as soon as you have determined whether the designs are the same." After reading this statement, the examiner presented the trial items.

All participants completed a demographics form. The demographics form contained questions about age, gender, education level, GPA, area of study, and occupation. The examiner read each question aloud to participants and recorded the answers.

Committee of Experts

Prior to the collection of any data for the project, a group of three experts were gathered to inspect subtest items on the TAP. The experts examined each item of each subtest and were asked to comment or voice concerns regarding the appropriateness of the items or any foreseeable difficulty participants who were blind might experience while completing the items.

The primary researcher presented the TAP subtests and the WAIS-IV to three individuals considered experts in the community of individuals who were blind. The criteria for being an expert were: 1) more than twenty years of experience living as an individual who was blind, 2) successful completion of nonvisual training, and 3) extensive experience working with, educating, and training other individuals who were

blind. The experts were asked to provide comments and feedback regarding all aspects of the TAP, from administration procedures to materials used to construct different items.

The experts met with the primary researcher on an individual basis. The average length of administration for the entire procedure was approximately four hours, but a considerable amount of this time was spent discussing various aspects of the TAP and the WAIS-IV. All three experts reported that he or she did not foresee an individual who was blind experiencing any problems completing the TAP or selected portions of the WAIS-IV due to inaccessibility or inappropriate selection of materials. Further, the experts reported he or she enjoyed the challenging nature of the TAP.

Procedure

After receiving Institutional Review Board approval, announcements were made about an opportunity to participate in the current research at the training center for individuals who were blind and several undergraduate psychology courses at a mid-sized Southern university. Participants were given the opportunity to sign up for time slots to complete the research. Participants received written and verbal informed consent information, and all data and identifying information were kept confidential. Participants completed the current research at the mid-sized Southern university's psychological services clinic, during hours that the clinic was not open to the public. After completion of all parts of the project, participants received twenty dollars cash as compensation.

Participants who were blind completed the Verbal Comprehension and Working Memory Indices of the WAIS-IV, the TAP subtests, and a demographic questionnaire. Participation required roughly two hours. Participants who were sighted completed the entire WAIS-IV, the TAP subtests, and a demographic questionnaire. Participation

required approximately two hours. All data collected were kept in a locked briefcase accessible only by the experimenter. When data were entered into electronic form for the purposes of statistical analysis, no identifying information was used and all files were password protected. The password was known only by the experimenter and the dissertation chair.

CHAPTER THREE

RESULTS

Scoring the TAP

Prior to statistical analyses, the primary researcher sought the best means by which to score the TAP. Part of the original intent of this project was to create a measure which could be used in conjunction with the WAIS-IV, thus it was decided to attempt similar scoring methods and verify these methods empirically. Specifically, the TAP subtests totals were calculated different ways and correlated with WAIS-IV indices and subtest scores. In addition, due to the large number of correlational analyses to be calculated, the investigator elected to forgo the usual significance testing because of concerns regarding the overinflating of alpha and also the risk of Type II error associated with correctional procedures such as the Bonferroni, as suggested by Field (2012).

Field (2012) suggested that significance testing was not the best means of evaluating numerous correlational analyses. He suggested researchers became so concerned over the possibility of making a Type I error that they applied conservative corrections such as the Bonferroni and instead made Type II errors. Field recommended evaluating correlation coefficients as the effect sizes they were and reporting them in terms of confidence intervals (CIs). Hence, the correlation coefficients for the current research were presented as well as 95% CIs.

Tactile Tile Design

Tactile tile design was based on the block design task of the WAIS-IV and it seemed logical that the scoring style should be similar as well. The block design task was scored by summing the correct number of responses produced by the examinee within a time limit, and on some items bonus points were applied for completing designs quickly. The Psychological Corporation (2008) reported the time limit for most block design items on the WAIS-IV was either one-minute or two-minutes for the later items.

For the purposes of the current study, the use of WAIS-IV time limits did not appear to be appropriate. Time limits of 90 and 180-seconds were used for the tactile tile design task. Thinking logically, it would require more time for a participant to scan a design area via tactile means than it would to do so visually. Further, a comparison of TAP tactile tile design scores with time limits set at 60 and 120-seconds and 90 and 180-seconds demonstrated that the 60 and 120-second time limits led to lower overall scores, ($t(62) = 4.27, p < .001$; Cohen's $d = 1.085$; $M = 6.86$, $SD = 3.68$ and $M = 9.48$, $SD = 3.27$, respectively). In addition, the scores calculated by using the 90 and 180-second time limits produced stronger correlations than the 60 and 120-second limit ($z = 2.14, p = .032$) when investigating the relationship between tactile tile design and block design in participants who were sighted ($r(30) = .635$; 95% CI [0.368, 0.805] and $r(30) = .17$; 95% CI [-0.190, 0.490], respectively).

Another aspect of WAIS-IV block design scoring to consider was the time bonus system. The Psychological Corporation (2008) indicated that if a participant was able to complete a block design item successfully and do so in a specified time period, then the participant was awarded time bonus points. Participants were awarded time bonus points

based on the WAIS-IV block design standards. If the participant successfully completed a tactile tile design item within the 90 or 180-second region as appropriate, then the participant was awarded one point. If the participant successfully completed a tactile tile design item within WAIS-IV block design standards to qualify for a time bonus, then the participant was awarded two points. This idea was validated empirically and the performance of participants on the tactile tile design task scored was compared with time bonus points and without time bonus points, with overall time limits set at 90 and 180-seconds as appropriate. Results of this comparison suggested there was no difference between the two scoring styles, ($t(62) = 0.39$, $p = .721$; Cohen's $d = 0.100$, $M = 9.48$, $SD = 3.27$ for the no time bonus scoring style and $M = 9.72$, $SD = 3.54$ for the time bonus scoring style). Further, analyses revealed no difference ($z = 0.09$, $p = .928$) between the strength of the relationship between tactile tile design scores with no time bonus and performance on the block design task ($r(30) = .635$; 95% CI [0.368, 0.805]) and tactile tile design scores with time bonus on the block design task ($r(30) = 620$; 95% CI [0.346, 0.797]). It may be possible that further research could support the use of time bonus scores, but a larger sample and precise tuning of the time criteria would be required as participants who met time bonus criteria were rare in the current sample.

Tactile Figure Exploration

Tactile figure exploration was based on the symbol search task of the WAIS-IV and it seemed logical that the scoring style should be similar as well. The Psychological Corporation (2008) reported the symbol search subtest of the WAIS-IV required participants to rapidly discern the presence or absence of specified symbols from a search area of multiple targets. The WAIS-IV standardization procedures dictated symbol search

was scored by summing the total number of correct responses achieved within a two-minute time limit and subtracting the number of incorrect responses from that total. Similar to the case of tactile tile design, the primary researcher was concerned that a two-minute time limit might not be appropriate for tactile figure exploration and investigated what limit would be best based on empirical and logistical means.

It was worth noting that there was a significant difference in the time required by participants to complete the entire tactile figure exploration task. Specifically, a MANOVA was conducted to investigate how quickly and accurately participants were able to complete the tactile figure exploration task and results indicated a difference based on participant's visual functioning (Wilk's $\Lambda = .547$, $F(2, 61) = 25.58$, $p < .001$, $\eta^2 = .45$). Participants who were blind completed the task much faster than participants who were sighted ($F(1, 62) = 49.46$, $p < .001$, $\eta^2 = .44$, $M = 581.16$-seconds, $SD = 282.93$ and $M = 1{,}110.47$, $SD = 318.166$, respectively; Tukey HSD $p < .001$). In addition, participants who were blind produced higher scores overall on tactile figure exploration than participants who were sighted ($F(1, 62) = 5.02$, $p = .028$, $\eta^2 = .08$, $M = 11.31$, $SD = 5.97$ and $M = 7.94$, $SD = 6.09$, respectively; Tukey HSD $p < .001$). These findings may be the result of participants who were sighted experiencing disorientation due to the loss of vision for this task and possibly those participants who were blind simply having more experience dealing with nonvisual tasks and being more efficient. These differences seemed to indicate that it would be best to consider potential scoring methods based on participant vision rather than grouping the entire sample together.

When considering participants who were blind, the primary researcher investigated the relationship among tactile figure exploration scores at two through

twenty-minute intervals and performance on WAIS-IV VCI and WMI indices. Pearson's *r* indicated positive relationships between tactile figure exploration at the eight-minute mark for the WMI ($r(30) = .623$; 95% CI [0.350, 0.798]) and the sixteen-minute mark for the VCI ($r(30) = .505$; 95% CI [0.190, 0.726]), but there was no difference between these relationships ($z = 0.66$, $p = .509$). However, the researcher's primary intent of the tactile figure exploration task was to capture the cognitive processing speed ability, and while The Psychological Corporation (2008) indicated the WMI may capture a little of that ability, the VCI did not. To more completely understand what the tactile figure exploration captured, it might be best to turn to the group of participants who were sighted.

The relationships among tactile figure exploration scores at two through twenty-minute intervals and scores on the symbol search, coding, and PSI of the WAIS-IV were investigated in the group of participants who were sighted. Pearson's *r* indicated a strong, positive relationship for symbol search and tactile figure exploration at nine-minutes ($r(30) = .627$; 95% CI [0.356, 0.801]). Results suggested a moderate, positive relationship between coding and tactile figure exploration at nine-minutes ($r(30) = .496$; 95% CI [0.178, 0.720]). Further, regarding the PSI, results indicated a moderately strong, positive relationship with the tactile figure exploration task at nine-minutes ($r(30) = .597$; 95% CI [0.314, 0.783]).

Overall, these results appeared to support a time limit of less than ten-minutes for the tactile figure exploration task. The aforementioned results indicated a time limit of eight-minutes might be most appropriate for participants who were blind when completing the tactile figure exploration task. However, further research was required

before that time limit was applied and forthcoming statistical analyses considered other potential time limits when investigating the tactile figure exploration subtest.

Tactile Matching

Tactile matching was based on the cancellation subtest of the WAIS-IV and logic dictated that the scoring style be similar as well. The Psychological Corporation (2008) asserted the cancellation task of the WAIS-IV required participants to respond correctly to items under a time constraint and incorrect responses were subtracted from the total number of correct responses. The tactile matching task consisted of two different phases and participant performance on those phases could be summed to produce an overall score.

In determining the best method for reporting tactile matching scores, the researcher first investigated whether there were group differences between participants based on vision. Specifically, a MANOVA was conducted to look for group differences in performance on tactile matching at different time intervals in phase one, phase two, and the combination of phase one and two. Results suggested differences were present (See Table 1).

Table 1

MANOVA for Differences in Tactile Matching Based on Vision

Variable	Wilk's Λ	F	df	Error df	η^2
Participant vision	0.471	5.596*	10	53	0.529
* = $p < .001$					

Phase one differences based on vision were found at two-minutes, three-minutes, four-minutes, and five-minutes. In each case participants who were blind demonstrated superior performance as compared to participants who were sighted (See Table 2).

Table 2

Univaritate Effects for Participant Vision on Tactile Matching Phase One

Dependent variable	*df*	Error *df*	*F*	η^2	Participant who is	Means	*SD*	95% CI Lower	Upper
Two minutes	1	62	27.067*	0.304	Blind	11.094	4.514	9.829	12.359
					Sighted	6.438	2.285	5.172	7.703
Three minutes	1	62	34.209*	0.356	Blind	14.563	4.655	13.173	15.952
					Sighted	8.813	3.042	7.423	10.202
Four minutes	1	62	24.177*	0.281	Blind	15.969	4.483	14.541	17.397
					Sighted	11.001	3.547	9.572	12.428
Five minutes	1	62	15.684*	0.202	Blind	16.469	4.318	15.031	17.908
					Sighted	12.438	3.809	10.999	13.876

* = $p < .001$, Tukey HSD post hoc comparisons all significant beyond $p < .001$ level

Phase two differences based on vision were found at two-minutes, three-minutes, four-minutes, and five-minutes. In each case participants who were blind demonstrated superior performance as compared to participants who were sighted (See Table 3).

Table 3

Univaritate Effects for Participant Vision on Tactile Matching Phase Two

Dependent variable	*df*	Error *df*	*F*	η^2	Participant who is	Means	*SD*	95% CI Lower	Upper
Two minutes	1	62	25.324*	0.291	Blind	10.781	5.053	9.359	12.203
					Sighted	5.719	2.615	4.297	7.141
Three minutes	1	62	21.182*	0.255	Blind	13.656	4.863	12.092	15.221
					Sighted	8.563	3.943	6.998	10.127
Four minutes	1	62	11.289*	0.154	Blind	14.501	4.265	12.949	16.051
					Sighted	10.813	4.511	9.261	12.364
Five minutes	1	62	9.001 (p = 0.004)	0.127	Blind	14.938	3.835	13.436	16.439
					Sighted	11.751	4.628	10.248	13.252

* = $p < .001$, Tukey HSD post hoc comparisons all significant beyond $p < .001$ level

Combined phase one and two scores appeared different based on participant vision at the two-minute scoring interval, at the three-minute scoring interval, at the four-minute scoring interval, and at the five-minute scoring interval. In each case participants who were blind demonstrated superior performance as compared to participants who were sighted (See Table 4).

Table 4

Univaritate Effects for Participant Vision on Tactile Matching Phase One and Two

Dependent variable	*df*	Error *df*	*F*	η^2	Participant who is	Means	*SD*	95% CI Lower	Upper
Two minutes	1	62	48.414*	0.438	Blind	21.656	6.449	19.701	23.612
					Sighted	12.031	4.432	10.076	13.987
Three minutes	1	62	31.231*	0.335	Blind	28.219	8.831	25.476	30.961
					Sighted	17.375	6.519	14.632	20.118
Four minutes	1	62	19.223*	0.237	Blind	30.469	7.984	27.678	33.259
					Sighted	21.813	7.811	19.022	24.603
Five minutes	1	62	13.068*	0.174	Blind	31.313	7.459	28.527	34.098
					Sighted	24.188	8.287	21.402	26.973

* = $p < .001$, Tukey HSD post hoc comparisons all significant beyond $p < .001$ level

These findings may again be the result of participants who were sighted experiencing some level of disorientation due to the loss of vision for this task and possibly the participants who were blind simply possessing more experience dealing with nonvisual tasks. These differences indicated that it would likely be best to consider potential scoring methods based on participant vision, rather than grouping the entire sample together.

When considering the tactile matching task, the performance of participants who were blind was correlated with their performance on the WAIS-IV VCI, WMI, and the subtests which made up those indices. Further, the researcher suspected that the two-minute time limit of the WAIS-IV cancellation task might not be appropriate for tactile matching and investigated scores collected during both phases at time intervals of two, three, four, five-minutes, and a combined phase one and two overall score.

Pearson's *r* was utilized to determine the presence and strength of relationships between the tactile matching subtest of the TAP and the WAIS-IV WMI of participants who were blind. Results suggested moderate, positive correlations among the WMI and tactile matching phase one at two-minutes, at three-minutes, at four-minutes, and at five-minutes (See Table 5).

Table 5

Pearson Correlations for Tactile Matching Phase One and WMI Scores in Participants Who were Blind

	2M	3M	4M	5M
WMI	.462	.556	.554	.508
	(.135, .698)	(.257, .758)	(.254, .757)	(.194, .728)

n = 32; WMI = Working Memory Index, 2M = two-minute score, 3M = three-minute score, 4M = four-minute score, 5M = five-minute score, 95% CIs in parentheses

Further investigation revealed moderate to weak, positive relationships among WMI scores and tactile matching combined phase one and two scores at three-minutes, at four-minutes, and at five-minutes (See Table 6).

Table 6

Pearson Correlations for Tactile Matching Combined and WMI Scores in Participants Who were Blind

	3M	4M	5M
WMI	.453	.433	.382
	(.124, .692)	(.099, .679)	(.038, .645)

n = 32; WMI = Working Memory Index, 3M = three-minute score, 4M = four-minute score, 5M = five-minute score, 95% CIs in parentheses

Tactile matching phase two scores failed to demonstrate a relationship with WMI scores at any time interval.

The relationships of the tactile matching task and VCI scores were investigated via Pearson's *r* in the group of participants who were blind. Analyses revealed weak to moderate, positive relationships between tactile matching phase one scores and VCI scores at two-minutes, three-minutes, four-minutes, and five-minutes (See Table 7).

Table 7

Pearson Correlations for Tactile Matching Phase One and VCI Scores in Participants Who were Blind

	2M	3M	4M	5M
VCI	.395	.379	.448	.473
	(.054, .654)	(.035, .643)	(.118, .689)	(.149, .705)

n = 32; VCI = Verbal Comprehension Index, 2M = two-minute score, 3M = three-minute score, 4M = four-minute score, 5M = five-minute score, 95% CIs in parentheses

No further relationships were discovered when investigating the tactile matching phase two and combined phase one and two scores; however, investigation of scores of individuals who were sighted might aid in deciding upon a scoring system.

Similar sets of analyses were conducted when investigating tactile matching scores produced by individuals who were sighted. When investigating the PSI scores Pearson's *r* indicated moderate, positive correlations with tactile matching phase one scores at two-minutes, three-minutes, four-minutes, and five-minutes (See Table 8).

Table 8

Pearson Correlations for Tactile Matching Phase One and PSI Scores in Participants Who were Sighted

	2M	3M	4M	5M
PSI	.527	.506	.433	.396
	(.218, .740)	(.191, .727)	(.099, .679)	(.055, .654)

n = 32; PSI = Processing Speed Index, 2M = two-minute score, 3M = three-minute score, 4M = four-minute score, 5M = five-minute score, 95% CIs in parentheses

Pearson's *r* revealed moderate, positive relationships with PSI scores and tactile matching phase two scores at four-minutes and five-minutes (See Table 9).

Table 9

Pearson Correlations for Tactile Matching Phase Two and PSI Scores in Participants Who were Sighted

	4M	5M
PSI	.413	.423
	(.075, .666)	(087, .673)

n = 32; PSI = Processing Speed Index, 4M = four-minute score, 5M = five-minute score, 95% CIs in parentheses

In addition, Pearson's *r* suggested moderate, positive correlations with PSI scores and tactile matching combined phase one and two scores at two-minutes, at three-minutes, at four-minutes, and at five-minutes (See Table 10).

Table 10

Pearson Correlations for Tactile Matching Combined and PSI Scores in Participants Who were Sighted

	2M	3M	4M	5M
PSI	.456	.446	.435	.418
	(.128, .694)	(.115, .688)	(.102, .680)	(.081, .669)

n = 32; PSI = Processing Speed Index, 2M = two-minute score, 3M = three-minute score, 4M = four-minute score, 5M = five-minute score, 95% CIs in parentheses

Further investigation of the best method for scoring tactile matching focused on WMI scores. When investigating WMI and tactile matching phase one scores at five-minutes in participants who were sighted, Pearson's *r* suggested a moderate, positive correlation. Pearson's *r* revealed moderate, positive correlations among WMI scores and tactile matching phase two scores at four-minutes and at five-minutes. The tactile

matching combined phase one and two scores demonstrated weak to moderate, positive correlations with WMI scores at intervals of three-minutes, four-minutes, and five-minutes (See Table 11).

Table 11

Pearson Correlations for Tactile Matching WMI Scores in Participants Who were Sighted

	Phase one 5M	Phase two 4M	Phase two 5M	Combined 3M	Combined 4M	Combined 5M
WMI	.415	.398	.419	.349	.350	.425
	(.078, .667)	(.057, .656)	(.082, .670)	(.000, .622)	(.001, .623)	(.090, .674)

n = 32; WMI = Working Memory Index, 3M = three-minutes, 4M = four-minutes, 5M = five-minutes, 95% CIs in parentheses

The researcher next explored the relationship between PRI and tactile matching via Pearson's *r* in participants who were sighted. A moderate, positive correlation was discovered between PRI scores and tactile matching phase two scores at five-minutes ($r(30) = .393$; 95% CI [0.051, 0.652]). A weak, positive relationship was found among PRI scores and tactile matching combined phase one and two scores at five-minutes ($r(30) = .373$; 95% CI [0.028, 0.639]).

The relationships between WAIS-IV symbol search scores and tactile matching scores of participants who were sighted were explored to further refine the scoring procedure of the TAP. Results indicated strong to moderate correlations among tactile matching phase one scores and symbol search at two-minutes, at three-minutes, at four-minutes, and at five-minutes (See Table 12).

Table 12

Pearson Correlations for Tactile Matching Phase One and Symbol Search in Participants Who were Sighted

	2M	3M	4M	5M
SS	.623	.592	.517	.434
	(.350, .798)	(.307, .780)	(.205, .733)	(.101, .680)

n = 32; SS = Symbol Search, 2M = two-minute score, 3M = three-minute score, 4M = four-minutes, 5M = five-minute score, 95% CIs in parentheses

Further analyses revealed moderate, positive correlations among tactile matching phase two scores and symbol search scores at three-minutes, at four-minutes, and at five-minutes (See Table 13).

Table 13

Pearson Correlations for Tactile Matching Phase Two and Symbol Search in Participants Who were Sighted

	3M	4M	5M
SS	.430	.460	.443
	(.096, .677)	(.133, .697)	(.112, .686)

n = 32; SS = Symbol Search, 2M = two-minute score, 3M = three-minute score, 4M = four-minutes, 95% CIs in parentheses

In addition, Pearson's *r* revealed moderate, positive correlations among tactile matching combined phase one and two scores and symbol search at two-minutes, at three-minutes, at four-minutes, and at five-minutes (See Table 14).

Table 14

Pearson Correlations for Tactile Matching Combined and Symbol Search in Participants Who were Sighted

	2M	3M	4M	5M
SS	.530	.536	.501	.447
	(.222, .742)	(.230, .745)	(.185, .723)	(.116, .688)

n = 32; SS = Symbol Search, 2M = two-minute score, 3M = three-minute score, 4M = four-minutes, 5M = five-minute score, 95% CIs in parentheses

Pearson's *r* was utilized to investigate the relationship between the tactile matching task of the TAP and the coding subtest of the WAIS-IV in participants who were sighted in an effort to determine the best method of scoring the TAP. Results suggested weak, positive relationships between tactile matching phase one scores and coding subtest scores at two-minutes ($r(30) = .371$; 95% CI [0.026, 0.637]) and at three-minutes ($r(30) = .362$; 95% CI [0.015, 0.631]). Tactile matching phase two and combined phase one and phase two scores failed to demonstrate a relationship with the coding subtest at any time interval.

The tactile matching task was originally intended to be a measure of cognitive processing speed. Hence, it made sense to refer heavily to the relationship between tactile matching and the PSI. It appeared that phase one of tactile matching demonstrated the strongest relationship with the PSI at the more brief time intervals. Similar results were noted when investigating the tactile matching combined phase one and two scores. The relationship between the tactile matching task and WMI was somewhat similar for participants who were blind and participants who were sighted. Specifically, tactile matching phase one, phase two, and combined scores demonstrated stronger relationships with WMI scores at higher time intervals. For the purposes of the current research,

numerous time intervals and scoring styles were analyzed when investigating the hypotheses.

Tactile Figure-Ground Identification

The tactile figure-ground identification subtest of the TAP was designed to measure fluid intelligence, cognitive processing speed, and short-term memory. A possible scoring method considered for tactile figure-ground identification was termed D2 (differences worth two), in which successfully identifying the presence of differences on items awarded the participant one point and another point for determining how the items were different for a total of two points.

Initial analyses investigated whether there was a difference between participants who were blind and participants who were sighted on the D2 scoring method. A MANOVA was conducted to determine the potential influence of participant vision on D2 scores. The results suggested a difference between participants who were sighted and participants who were blind (See Table 15).

Table 15

MANOVA for Differences in Tactile Figure Ground Identification Based on Vision

Variable	Wilk's Λ	*F*	*df*	Error *df*	η^2
Participant vision	0.821	6.659*	2	61	0.179

* = $p < .001$

Further investigation revealed a significant difference between D2 scores, in which participants who were blind produced higher scores than participants who were sighted (See Table 16).

Table 16

Univaritate Effects for Participant Vision on Tactile Figure Ground Identification

DV	*df*	Error *df*	*F*	η^2	*p*	Participant who is	Means	*SD*	95% CI Lower	Upper
D2	1	62	4.738	0.071	0.033*	Blind	14.502	2.243	13.638	15.362
						Sighted	13.172	2.623	12.309	14.034

* = Tukey HSD post hoc comparison significant at $p = .004$

This difference suggested it might be worthwhile to consider potential scoring methods based on participant vision, rather than grouping the entire sample together for the D2 scoring method.

The performance of participants who were blind on the tactile figure-ground identification task was correlated with their performance on the WAIS-IV VCI, WMI, and the subtests which composed those indices. Pearson's *r* revealed moderate to weak, positive correlations among the D2 scoring method and WMI scores ($r(30) = .472$; 95% CI [0.148, 0.705]), vocabulary subtest scores ($r(30) = .394$; 95% CI [0.053, 0.653]), and the digit span subtest ($r(30) = .385$; 95% CI [0.042, 0.647]).

Pearson's *r* was used to investigate the relationship among the performance of participants who were sighted on the tactile figure-ground exploration subtest and WAIS-IV indices and subtests using the D2 scoring method. Moderate to weak, positive correlations were discovered among the D2 scoring method and the VCI, the WMI, the PRI, and the PSI. In addition, weak to moderate correlations were found among the D2 scoring method and digit span, vocabulary, block design, and symbol search (See Table 17).

Table 17

Pearson Correlations for TFGE D2 and WAIS-IV Indices and Subtests in Participants Who were Sighted

	VCI	WMI	PRI	PSI	DS	VC	BD	SS
TFGE	.358	.485	.394	.397	.555	.527	.539	.385
	(.011, .628)	(.164, .713)	(.053, .653)	(.056, .655)	(.256, .757)	(.218, .740)	(.234, .747)	(.042, .647)

n = 32; VCI = Verbal Comprehension Index, WMI = Working Memory Index, PRI = Perceptual Reasoning Index, PSI = Processing Speed Index, DS = Digit Span, VC = Vocabulary, BD = Block Design, SS = Symbol Search, TFGE = Tactile Figure-Ground Exploration, 95% CIs in parentheses

Once the proof of concept for the use of the TAP has been established, it may be worth investigating different scoring methods involving time constraints and differing scoring weights for participant performance.

Tactile Block Configurations

The tactile block configurations task of the TAP was designed to capture fluid intelligence, cognitive processing speed, and short-term memory. Similar to tactile figure-ground identification, the first scoring method was termed D1 (differences worth one), in which successfully identifying the presence of differences on items awarded the participant half a point and half a point for determining how the items were different for a total of one point.

Prior to investigating potential correlations between the WAIS-IV and tactile block configurations, a MANOVA was conducted to determine whether there were differences between the performance of participants who were blind and participants who were sighted using the D1 scoring method. The MANOVA indicated no differences between participant performance (Wilk's $\Lambda = .972$, $F(2, 61) = .863$, $p = .427$). The results

suggested that the participant groups were roughly the same and might be combined to best identify the most appropriate scoring method for tactile block configurations.

The D1 scoring method was investigated using the entire sample when appropriate (i.e., when the WAIS-IV subtests and indices could be completed by all participants). Pearson's *r* revealed moderate, positive correlations among the tactile block configurations D1 scoring method and the VCI, the PRI, and the WMI (See Table 18).

Table 18

Pearson Correlations for TBC D1 Scoring and WAIS-IV Indices

	VCI	PRI	WMI
TBC	.505	.436*	.484
	(.296, .668)	(.103, .681)	(.270, .652)

N = 64, VCI = Verbal Comprehension Index, PRI = Perceptual Reasoning Index, WMI = Working Memory Index, TBC = Tactile Block Configurations,

* = *n*=32 as only sighted participants could complete PRI, 95% CIs in parentheses

Further investigation demonstrated moderate to weak, positive correlations among the D1 scoring method and the block design subtest, similarities subtest, digit span subtest, vocabulary subtest, arithmetic subtest, and information subtest (See Table 19).

Table 19

Pearson Correlations for TBC D1 Scoring and WAIS-IV Subtest Scores

	BD	SI	DS	VC	AR	IN
TBC	.516*	.501	.418	.476	.380	.368
	(.204, .733)	(.291, .665)	(.192, .602)	(.261, .646)	(.148, .572)	(.134, .563)

N = 64, BD = Block Design, SI = Similarities, DS = Digit Span, VC = Vocabulary, AR = Arithmetic, IN = Information, TBC = Tactile Block Configurations,

* = *n*=32 as only sighted participants could complete BD, 95% CIs in parentheses

Again, once the proof of concept for the use of the TAP has been established, it might be worth investigating different scoring methods involving time constraints and differing scoring weights for participant performance.

Preliminary Analyses

Prior to hypothesis testing, all measures were scored according to the respective standardization procedures and the data were thoroughly screened for entry errors. A MANOVA was conducted to investigate the influence of order of administration of the TAP and WAIS-IV on participant VCI scores, WMI scores, and TAP subtest scores, but failed to demonstrate any differences between scores (Wilk's $\Lambda = .841$, $F(1, 62) = 1.230$, $p = .301$). These results indicated that scores were similar regardless of which measure was completed first. In addition, for each of the statistical analyses conducted it was investigated whether violations of the assumption of normality occurred. There were no indications of any such violations.

The use of the achievement striving and conscientiousness indices of Costa and McCrae's (1992) NEO-PI-R were investigated because there was little available information regarding the use of those measures with participants who were blind. Specifically, a MANOVA was conducted to investigate any potential differences between participants who were blind and participants who were sighted when completing the achievement striving and conscientiousness measures, but failed to demonstrate any differences between scores (Wilk's $\Lambda = .984$, $F(2, 61) = .486$, $p = .617$). The results suggested that participant groups could likely be combined to further investigate the reliability of measures, but the use of the achievement striving and conscientiousness scales were investigated with each participant group for exploratory purposes.

Item Difficulty

In an effort to further investigate the administration procedure of the TAP to individuals who were blind, item difficulties were calculated where appropriate. Due to the nature of the tactile matching task, item difficulty could not be calculated. Item difficulty figures for tactile tile design ranged from .39 to 1.00 (See Table 20).

Table 20

Tactile Tile Design Item Difficulties

Item	Difficulty
a	1.00
b	0.91
T1	0.68
c	0.84
d	0.84
1	0.77
2	0.97
3	0.81
4	0.87
5	0.81
6	0.74
7	0.39
8	0.52
9	0.71
10	0.58

Tactile figure exploration item difficulty figures ranged from .45 to .94 (See Table 21).

Table 21

Tactile Figure Exploration Item Difficulties

Item	Difficulty
1	0.94
2	0.77
3	0.84
4	0.84
5	0.87
6	0.74
7	0.84
8	0.68
9	0.74
10	0.45
11	0.87
12	0.74
13	0.91
14	0.58
15	0.71
16	0.74
17	0.81
18	0.71
19	0.87
20	0.65
21	0.58

Tactile figure ground item difficulty calculations ranged from .31 to .91 (See Table 22).

Table 22

Tactile Figure Ground Item Difficulties

Item	Difficulty
1	0.88
2	0.78
3	0.75
4	0.78
5	0.81
6	0.38
7	0.91
8	0.84
9	0.59
10	0.88
11	0.72
12	0.69
13	0.31

Tactile block configuration item difficulty figures ranged from .35 to 1.00 (See Table 23).

Table 23

Tactile Block Configurations Item Difficulty

Item	Difficulty
1	1.00
2	0.97
3	1.00
4	0.94
5	0.81
6	0.35
7	0.84
8	0.58
9	0.61
10	0.74
11	0.61
12	0.58
13	0.68
14	0.61
15	0.74
16	0.48
17	0.74
18	0.42

Overall, it appeared that all of the TAP subtests lacked the difficulty often seen in WAIS-IV subtests. The Psychological Corporation (2008) indicated that when administering the WAIS-IV it was unusual for participants to successfully complete the last few items of the subtests.

Demographics

Demographics information can be found in Table 24. The mean length of experience living as a person who was blind was 27.31 years with a standard deviation of 16.78. Of the participants who were blind, the mean amount of experience as a person who was sighted was 9.8 years with a standard deviation of 15. The visual acuity of all participants who were sighted was 20/20.

Table 24

Demographics

	Overall	Participants who are Blind	Participants who are Sighted
N	64	32	32
Mean age (*SD*)	29.8 (12.9)	37.6 (14.3)	22 (2.7)
Years of education (*SD*)	14.33 (1.4)	14.47 (1.7)	14.9 (1)
GPA (*SD*)	3.32 (.50)	3.41 (.50)	3.23 (.49)
Nonvisual training in months (*SD*)		6.5 (3)	N/A
Duration of blindness in years (*SD*)		27.31 (16.78)	N/A

Pearson's *r* was calculated to investigate potential relationships among the amount of experience a participant possessed living as a person who was blind and living

as a person who was sighted in completing the TAP. Overall, weak, positive relationships were found between length of experience living as a person who was blind and performance on the TAP subtests (See Table 25).

Table 25

Correlations for LoE as a Blind Person and TAP Scores in Participants Who were Blind

	TTD	TFE 8M	TM P1 2M	TM P2 2M	TFGI D2	TBC D1
LoE	.175	.194	.300	.313	.248	.206
	(-.185, .494)	(-0.166, .508)	(-0.054, .587)	(-0.040, .597)	(-0.110, .549)	(-0.154, .518)

n = 32; LoE = Length of Experience, TTD = Tactile Block Design, Tactile Figure Exploration at 8-minutes, Tactile Matching Phase One two-minutes, Tactile Matching Phase Two two-minutes, Tactile Figure Ground Identification D2 scoring, Tactile Block Configurations D1 scoring, 95% CIs in parentheses

In addition, Pearson's *r* was calculated to investigate the relationships among TAP subtests and the length of experience as a sighted person in the group of participants who were blind. Results revealed weak to moderate, negative relationships among performance on TAP subtests and the amount of experience living as a person who was sighted in participants who were blind See Table 26).

Table 26

Correlations for LoE as a Sighted Person and TAP Scores in Participants Who were Blind

	TTD	TFE 8M	TM P1 2M	TM P2 2M	TFGI D2	TBC D1
LoE	-.202	-.394	-.433	-.462	-.454	-.292
	(-.514, .158)	(-.653, -.053)	(-.679, -.099)	(-.698, -.135)	(-.693, -.125)	(-.581, .063)

n = 32; LoE = Length of Experience, TTD = Tactile Block Design, Tactile Figure Exploration at 8-minutes, Tactile Matching Phase One two-minutes, Tactile Matching Phase Two two-minutes, Tactile Figure Ground Identification D2 scoring, Tactile Block Configurations D1 scoring, 95% CIs in parentheses

Further, Pearson's *r* was calculated to investigate the relationships among TAP subtests and the length of experience as a sighted person in the group of participants who were sighted. Results suggested weak to moderate, negative correlations among performance on TAP subtests and the length of experience as a sighted person in participants who were sighted (See Table 27).

Table 27

Correlations for LoE as a Sighted Person and TAP Scores in Participants Who were Sighted

	TTD	TFE 8M	TM P1 2M	TM P2 2M	TFGI D2	TBC D1
LoE	-.333	-.278	-.375	-.421	-.583	-.184
	(-.611, .018)	(-.571, .078)	(-.640, -.030)	(-.671, -.085)	(-.774, -.294)	(-.501, .176)

n = 32; LoE = Length of Experience, TTD = Tactile Block Design, Tactile Figure Exploration at 8-minutes, Tactile Matching Phase One two-minutes, Tactile Matching Phase Two two-minutes, Tactile Figure Ground Identification D2 scoring, Tactile Block Configurations D1 scoring, 95% CIs in parentheses

Overall, it appeared that regardless of whether a participant was a person who was blind or a person who was sighted, length of experience living as a person who was sighted demonstrated a negative relationship with performance on TAP subtests. Further, the amount of experience a participant who was blind possessed living as an individual who was blind correlated positively with performance on TAP subtests. This might indicate the TAP was a disorienting experience to individuals who were sighted, as was previously suspected. However, these results might also indicate the TAP was capturing abilities not typically used by participants who were sighted. The weak, positive relationship between length of experience living as a person who was blind and performance on the TAP might indicate the TAP was capturing aspects of abilities

participants who were blind have refined or developed more than participants who were sighted, perhaps the abilities once described by Spearman (1904).

Hypothesis One

H_1 predicted that there would be positive correlations among the PRI and PSI of the WAIS-IV and the TAP subtests, when completed by individuals who were sighted. This hypothesis was partially supported. Specifically, Pearson's *r* revealed positive correlations among the PRI and several of the TAP subtests including: tactile tile design with time limits set at 90 and 180-seconds, tactile figure exploration at six-minutes and ten-minutes, tactile matching phase two at five-minutes and tactile matching phase one and two combined at five-minutes, and tactile figure-ground identification D2 scoring method, and tactile block configuration D1 scoring method (See Table 28).

Table 28

Pearson Correlations for Hypothesis One: PRI Scores

	TTD	TFE 6M	TFE 10M	TM P2 5M	TM C 5M	TFGI D2	TBC D1
PRI	.462	.556	.554	.508	.556	.554	.508
	(.135, .698)	(.257, .758)	(.254, .757)	(.194, .728)	(.257, .758)	(.254, .757)	(.194, .728)

n = 32; TTD = Tactile Tile Design, TFE 6M = Tactile Figure Exploration at six-minutes, TFE 10M = Tactile Figure Exploration at ten-minutes, TM P2 5M = Tactile Matching Phase two at five-minutes, TFGI D2 = Tactile Figure-Ground Identification D2 scoring, PRI = Perceptual Reasoning Index, TBC D1 = Tactile Block Configurations D1 scoring, 95% CIs in parentheses

The second half of H_1 called for positive correlations among the PSI and the TAP subtests when completed by participants who were sighted. Pearson's *r* suggested that this part of the hypothesis was partially supported. Specifically, there was no relationship found between the PSI and the tactile block configurations task using the D1 scoring method. However, the other subtests of the TAP did produce positive relationships when

correlated with the PSI, including: the tactile figure exploration task at nine-minutes, tactile matching phase one at two-minutes, tactile matching phase two at five-minutes, tactile matching phase one and two combined at two-minutes, and tactile figure-ground identification using the D2 scoring method (See Table 29).

Table 29

Pearson Correlations for Hypothesis One: PSI Scores

	TBC D1	TFE 9M	TM P1 2M	TM P2 5M	TM C 2M	TFGI D2
PSI	.101	.597	.527	.423	.456	.397
	(-.257, .434)	(.314, .783)	(.218, .740)	(.087, .673)	(.128, .694)	(.056, .655)

n = 32; Tactile Block Configurations D1 scoring, TFE 9M = Tactile Figure Exploration at 9-minutes, TM = Tactile Matching Phase one at two-minutes, TM P2 5M = Tactile Matching phase two at five-minutes, TM C 2M = Tactile Matching Combined at two-minutes, Tactile Figure-Ground Identification D2 scoring, 95% CIs in parentheses

Hypothesis Two

H_2 predicted there would be positive correlations among the WAIS-IV subtests block design, matrix reasoning, symbol search, visual puzzles, and coding and the TAP subtests in participants who were sighted. This hypothesis was partially supported. Pearson's *r* revealed positive correlations among the block design subtest and tactile tile design with time limits set at 90 and 180-seconds, tactile figure exploration at six-minutes, tactile matching phase one at three-minutes, tactile matching phase two at five-minutes, tactile matching phase one and two combined at five-minutes, tactile figure-ground identification using the D2 scoring method, and tactile block configurations using the D1 scoring method (See Table 30).

Table 30

Pearson Correlations for Hypothesis Two: BD and TAP Subtests

	TTD	TFE 6M	TM P1 3M	TM P2 5M	TM C 5M	TFGI D2	TBC D1
BD	.462	.556	.554	.508	.556	.554	.508
	(.135, .698)	(.257, .758)	(.254, .757)	(.194, .728)	(.257, .758)	(.254, .757)	(.194, .728)

n = 32; TTD = Tactile Tile Design, TFE 6M = Tactile Figure Exploration at six-minutes, TM P1 3M = Tactile Matching Phase one at three-minutes, TM P2 5M = Tactile Matching Phase two at five-minutes, TM C 5M = Tactile Matching Combined at five-minutes, TFGI D2 = Figure-Ground Identification D2 scoring, TBC D1 = Tactile Block Configurations D1 scoring, BD = Block Design, 95% CIs in parentheses

Pearson's *r* was utilized to further investigate the validity of H_2. The matrix reasoning subtest performance of participants who were sighted was correlated with TAP subtest scores and revealed there was no relationship with tactile tile design when time limits were set at 90 and 180-seconds ($r(30) = .270$; 95% CI [-0.087, 0.565]), tactile figure-ground identification using the D2 scoring method ($r(30) = .162$; 95% CI [-0.198, 0.483]), and tactile block configurations using the D1 scoring method ($r(30) = .219$; 95% CI [-0.140, 0.527]). In addition, there were no relationships between the matrix reasoning subtest and the tactile figure exploration task at any time interval. There were no relationships among the matrix reasoning subtest and the tactile matching task at any phase or time interval.

Further analyses via Pearson's *r* investigated the relationships among the symbol search subtest and the subtests of the TAP. Pearson's *r* revealed a very weak, positive relationship when investigating symbol search and tactile tile design using the 90 and 180-second time limits. There was no relationship between the tactile block configurations task using the D1 scoring method and symbol search. Results indicated positive correlations among the symbol search subtest and tactile figure exploration at nine-minutes, tactile matching phase one at two-minutes, tactile matching phase two at

four-minutes, tactile matching phase one and two combined at three-minutes, and tactile figure-ground identification using the D2 scoring method (See Table 31).

Table 31

Pearson Correlations for Hypothesis Two: SS and TAP Subtests

	TTD	TFE 9M	TM P1 2M	TM P2 4M	TM C 3M	TFGI D2	TBC D1
SS	.302	.627	.623	.460	.536	.385	.090
	(-.052, .589)	(.356, .801)	(.350, .798)	(.133, .697)	(.230, .745)	(.042, .647)	(-.267, .425)

Additional analyses focused on the relationships among the visual puzzles subtest and the TAP subtests. Pearson's *r* failed to reveal a relationship between the visual puzzles subtest and the tactile tile design task with time limits set to 90 and 180-seconds ($r(30) = .257$; 95% CI [-0.101, 0.556]). Results did not support relationships among visual puzzles and tactile figure-ground identification using the D2 scoring method ($r(30) = .079$; 95% CI [-0.277, 0.416]) as well as tactile block configuration using the D1 scoring method ($r(30) = .166$; 95% CI [-0.194, 0.487]). There were no relationships among visual puzzles and tactile figure exploration at any time interval. There were no correlations among visual puzzles and tactile matching at any phase or time interval.

Pearson's *r* was utilized to determine the presence of correlations among the coding subtest and the TAP subtests. There was a very weak, positive relationship between coding and tactile tile design with time limits at 90 and 180-seconds. There was a very weak, positive relationship between coding and tactile block configuration using the D1 scoring method. Results suggested a weak, positive relationship between coding and tactile figure-ground identification using the D2 scoring method. Results indicated a positive relationship between coding and tactile figure exploration at nine-minutes. There

was a positive correlation found between coding and tactile matching phase one at two-minutes, but not tactile matching phase two nor a combination of phase one and phase two (See Table 32).

Table 32

Pearson Correlations for Hypothesis Two: Coding and TAP Subtests

	TTD	TFE 9M	TM P1 2M	TFGI D2	TBC D1
Coding	.294	.496	.371	.339	.102
	(-.061, .583)	(.178, .720)	(.026, .637)	(-.011, .615)	(-.256, .435)

n = 32; TTD = Tactile Tile Design, TFE 9M = Tactile Figure Exploration at nine-minutes, TM P1 2M = Tactile Matching Phase one at two-minutes, TFGI D2 = Tactile Figure-Ground Identification D2 scoring, TBC D1 = Tactile Block Configurations D1 scoring, 95% CIs in parentheses

Hypothesis Three

H_3 predicted that scores on the WAIS-IV VCI and WMI would correlate positively with scores on TAP subtests when completed by individuals who were blind. Results indicated this hypothesis was partially supported. Specifically, Pearson's *r* revealed relationships among the VCI and tactile tile design with time limits set at 90 and 180-seconds, tactile figure exploration at nine-minutes, and tactile matching phase one at five-minutes, but not tactile matching phase two or tactile matching phase one and two combined at any time interval. There was a weak, positive relationship between the VCI and tactile figure-ground identification using the D2 scoring method. There was a positive correlation between the VCI and tactile block configuration using the D1 scoring method (See Table 33).

Table 33

Pearson Correlations for Hypothesis Three: VCI and TAP Subtests in Participants Who were Blind

	TTD	TFE 9M	TM P1 5M	TFGI D2	TBC D1
VCI	.413	.490	.473	.339	.466
	(.075, .666)	(.170, .716)	(.149, .705)	(-.011, .615)	(.140, .701)

n = 32; TTD = Tactile Tile Design, TFE 9M = Tactile Figure Exploration at nine-minutes, TM P1 5M = Tactile Matching Phase one at five-minutes, TFGI D2 = Tactile Figure-Ground Identification D2 scoring, TBC D1 = Tactile Block Configurations D1 scoring, VCI = Verbal Comprehension Index, 95% CIs in parentheses

Further analyses via Pearson's *r* were conducted to investigate the validity of H_3. Positive correlations were found among the WMI and tactile tile design using the 90 and 180-second time limits, tactile figure exploration at eight-minutes, tactile matching phase one at three-minutes, tactile matching phase one and phase two combined at three-minutes, tactile figure-ground using the D2 scoring method, and tactile block configuration using the D1 scoring method. There was no relationship found between the WMI and tactile matching phase two at any time interval (See Table 34).

Table 34

Pearson Correlations for Hypothesis Three: WMI and TAP Subtests in Participants Who were Blind

	TTD	TFE 8M	TM P1 3M	TM C 3M	TFGI D2	TBC D1
WMI	.462	.623	.556	.453	.472	.532
	(.135, .698)	(.350, .798)	(.257, .758)	(.124, .692)	(.148, .705)	(.225, .743)

n = 32; TTD = Tactile Tile Design, TFE 8M = Tactile Figure Exploration at eight-minutes, TM P1 3M = Tactile Matching Phase one at three-minutes, TM C 3M = Tactile Matching Combined at three-minutes, TFGI D2 = Tactile Figure-Ground Identification D2 scoring, TBC D1 = Tactile Block Configurations D1 scoring, WMI = Working Memory Index, 95% CIs in parentheses

Hypothesis Four

H_4 predicted that scores on the WAIS-IV similarities, digit span, vocabulary, arithmetic, and information would correlate positively with scores on TAP subtests when completed by individuals who were blind. Pearson's *r* was used to investigate the potential relationships of the WAIS-IV subtest and the TAP subtests. Results indicated this hypothesis was partially supported. Specifically, the similarities subtest demonstrated positive relationships with tactile tile design using the 90 and 180-second time limits ($r(30) = .411$; 95% CI [0.073, 0.664]), tactile figure exploration at eight-minutes ($r(30) = .381$; 95% CI [0.037, 0.644]), tactile matching phase one at four-minutes ($r(30) = .428$; 95% CI [0.093, 0.676]), and tactile block configurations using the D1 scoring method ($r(30) = .507$; 95% CI [0.192, 0.727]). There were no relationships found among similarities and tactile matching phase two, tactile matching phase one and two combined, and tactile figure-ground identification.

Further analyses via Pearson's *r* were utilized to investigate H_4. Results indicated there was a weak, positive relationship between digit span and tactile tile design using the 90 and 180-second time limits. In addition, there were no relationships found among digit span and tactile matching phase two and tactile matching phase one and phase two combined at any time interval. However, there were positive relationships between digit span and tactile figure exploration at eight-minutes, tactile matching phase one at four-minutes, tactile figure-ground identification using the D2 scoring method, and tactile block configuration using the D1 scoring method (See Table 35).

Table 35

Pearson Correlations for Hypothesis Four: DS and TAP Subtests in Participants Who were Blind

	TTD	TFE 8M	TM P1 4M	TFGI D2	TBC D1
DS	.325	.486	.385	.385	.411
	(-.027, .605)	(.165, .714)	(.042, .647)	(.042, .647)	(.073, .664)

n = 32; TTD = Tactile Tile Design, TFE 8M = Tactile Figure Exploration at eight-minutes, TM P1 4M = Tactile Matching Phase one at four-minutes, TFGI D2 = Tactile Figure-Ground Identification D2 scoring, TBC D1 = Tactile Block Configurations D1 scoring, DS = Digit Span, 95% CIs in parentheses

Additional analyses via Pearson's *r* focused on the relationships among the vocabulary subtest and the subtests of the TAP. Results suggested positive relationships among the vocabulary subtest and tactile tile design using the 90 and 180-second time limits, tactile figure exploration at eight-minutes, tactile matching phase one at three-minutes, tactile matching phase one and two combined at four-minutes, tactile figure-ground identification using the D2 scoring method, and tactile block configuration using the D1 scoring method. There was no relationship found between vocabulary and tactile matching phase two at any time interval (See Table 36).

Table 36

Pearson Correlations for Hypothesis Four: VC and TAP Subtests in Participants Who were Blind

	TTD	TFE 8M	TM P1 3M	TM C 4M	TFGI D2	TBC D1
VC	.402	.500	.399	.385	.394	.436
	(.062, .658)	(.183, .723)	(.058, .656)	(.042, .647)	(.053, .653)	(.103, .681)

n = 32; TTD = Tactile Tile Design, TFE 8M = Tactile Figure Exploration at eight-minutes, TM P1 3M = Tactile Matching Phase one at three-minutes, TM C 4M = Tactile Matching Combined at four-minutes, TFGI D2 = Tactile Figure-Ground Identification D2 scoring, TBC D1 = Tactile Block Configurations D1 scoring, VC = Vocabulary 95% CIs in parentheses

The relationships among the arithmetic subtest and the TAP subtests were also investigated via Pearson's *r*. There was no relationship found between arithmetic and tactile matching phase two at any time interval. Positive relationships were found among the arithmetic subtest and tactile tile design using the 90 and 180-second time limits, tactile figure exploration at eight-minutes, tactile matching phase one at three-minutes, tactile matching phase one and two combined at three-minutes, tactile figure-ground identification using the D2 scoring method, and tactile block configuration using the D1 scoring method (See Table 37).

Table 37

Pearson Correlations for Hypothesis Four: AR and TAP Subtests in Participants Who were Blind

	TTD	TFE 8M	TM P1 3M	TM C 4M	TFGI D2	TBC D1
AR	.471	.564	.598	.461	.409	.485
	(.146, .704)	(.268, .763)	(.315, .783)	(.134, .698)	(.070, .663)	(.164, .713)

n = 32; TTD = Tactile Tile Design, TFE 8M = Tactile Figure Exploration at eight-minutes, TM P1 3M = Tactile Matching Phase one at three-minutes, TM C 4M = Tactile Matching Combined at four-minutes, TFGI D2 = Tactile Figure-Ground Identification D2 scoring, TBC D1 = Tactile Block Configurations D1 scoring, AR = Arithmetic, 95% CIs in parentheses

Pearson's *r* was utilized to investigate the relationship between the information subtest and the TAP subtests. There was a weak, positive correlation found between information and tactile tile design with time limits set at 90 and 180-seconds. There was a weak, positive relationship between information and tactile figure-ground identification using the D2 scoring method. There were no relationships found among information and tactile matching phase one at any time interval as well as tactile matching phase two at any time interval, but there was a positive relationship between information and tactile matching phase one and two combined at two-minutes. There was a weak, positive

relationship found between information and tactile figure exploration at eight-minutes. A weak, positive relationship was found between information and tactile block configuration using the D1 scoring method (See Table 38).

Table 38

Pearson Correlations for Hypothesis Four: IN and TAP Subtests in Participants Who were Blind

	TTD	TFE 8M	TM C 2M	TFGI D2	TBC D1
IN	.299	.397	.357	.320	.374
	(-.055, .587)	(.056, .655)	(.009, .628)	(-.032, .602)	(.029, .639)

n = 32; TTD = Tactile Tile Design, TFE 8M = Tactile Figure Exploration at eight-minutes, TM C 2M = Tactile Matching Combined at two-minutes, TFGI D2 = Tactile Figure-Ground Identification D2 scoring, TBC D1 = Tactile Block Configurations D1 scoring, IN = Information, 95% CIs in parentheses

Hypothesis Five

H_5 predicted scores on measures of conscientiousness and achievement striving would not correlate with any TAP subtests, but participant GPA would. Pearson's *r* suggested H_5 was partially supported. A weak, positive correlation was found between participant GPA and tactile tile design using the 90 and 180-second time limits. A moderate, positive correlation was found between participant GPA and tactile figure exploration at eight-minutes. Weak, positive correlations were found among participant GPA and tactile matching phase one at five-minutes, tactile matching phase two at five-minutes, and tactile matching phase one and two combined at five-minutes. There were no relationships among participant GPA and tactile figure-ground identification using the D2 scoring method as well as tactile block configurations using the D1 scoring method (See Table 39).

Table 39

Pearson Correlations for Hypothesis Five: GPA and TAP Subtests

	TTD	TFE 8M	TM P1 5M	TM P2 5M	TM C 5M	TFGI D2	TBC D1
GPA	.370	.400	.300	.258	.285	-.080	-.010
	(.137, .564)	(.171, .588)	(.059, .508)	(.013, .474)	(.042, .496)	(-.320, .169)	(-.255, .236)

N = 64; TTD = Tactile Tile Design, TFE 8M = Tactile Figure Exploration at eight-minutes, TM P1 5M = Tactile Matching Phase one at five-minutes, TM P2 5M = Tactile Matching Phase two at five-minutes, TM C 5M = Tactile Matching Combined at five-minutes, TFGI D2 = Tactile Figure-Ground Identification D2 scoring, TBC D1 = Tactile Block Configurations D1 scoring, 95% CIs in parentheses

Further investigation focused on the relationships among the TAP subtests and achievement striving as well as conscientiousness. Pearson's *r* failed to reveal any relationships among the TAP subtests and the achievement striving and conscientiousness measures.

CHAPTER FOUR

DISCUSSION

Purpose

The current study undertook the development a performance-based intellectual assessment, designed for individuals who were blind. Specifically, the convergent and divergent validity of the Tactile Assessment of Performance were investigated by administering selected WAIS-IV subtests as well as measures of achievement striving, conscientiousness, and the Barona estimate of intellectual functioning. Further, reliability estimates were calculated for all measures, when possible. Results indicated partial support for all hypotheses.

Multitrait-Multimethod Matrix

The MTMM was utilized in an effort to demonstrate the construct validity of the TAP. The construct of intelligence was assessed via four different methods: individual administration of performance-based measures one may complete whether the individual was blind or sighted (i.e., the WAIS-IV subtests similarities, vocabulary, information, arithmetic, and digit span), individual administration of performance-based measures one may complete as an individual who was blind (i.e., the TAP subtests), survey (i.e., achievement striving and conscientiousness), self-report (i.e., participant GPA), and demographic data (i.e., the Barona). The original MTMM proposed by Campbell and

Fiske (1959) called for a symmetrical matrix, but for the current research this was not possible. There were no validated measures available to assess performance-based intellectual ability in individuals who were blind, thus the MTMM could not be fully crossed and symmetrical. Further, due to time and resource limitations reliability coefficients could not be gathered for all subtests. The modified MTMM using the overall sample may be viewed in Table 40. Modified multitrait-multimethod matrices for participants who were blind and participants who were sighted were also constructed for exploratory purposes. Overall, it appeared that the TAP was capturing aspects of intellectual functioning and demonstrated both convergent and divergent validity.

The reliability of the TAP as well as the WAIS-IV subtests, achievement striving, and conscientiousness measures were calculated as part of the modified MTMM monotrait-monomethod blocks. Due to limited resources, only split-half reliabilities were calculated for the subtests of the WAIS-IV and TAP. Without test-retest reliabilities the overall consistency of the TAP remained somewhat in question, but the available date were promising. The WAIS-IV subtests demonstrated good split-half reliabilities; specifically all were at or above .79. The tactile tile design task of the TAP demonstrated a split-half reliability of .72, which was considered acceptable according to Nunnally and Bernstein (1994). The tactile figure-ground identification task and tactile block configuration tasks suggested low split-half reliability by producing figures of .57 and .59, respectively. Reliability coefficients for tactile figure exploration and tactile matching could not be computed as they would require test-retest reliability. Further, it was worth noting that the split-half reliability coefficient was not the best reliability coefficient to use with the TAP and WAIS-IV subtests. The best reliability figure would

be test-retest, but those figures were not obtained. According to Nunnally and Bernstein's standards, the achievement striving and conscientiousness measures produced acceptable Cronbach's α figures of .77 and .76, respectively. The reliability of participant GPA and the Barona estimate of intelligence could not be calculated as they would have required test-retest reliability.

The convergent validity of the TAP was investigated by examining the monotrait-heteromethod blocks, specifically the relationship between the TAP, WAIS-IV subtests that could be completed by all participants, participant GPA, and the Barona estimate of intellectual functioning. The tactile tile design task scored with time limits set at 90 and 180-seconds produced positive correlations with all of the WAIS-IV subtests included in the analyses. Further, tactile tile design demonstrated, positive relationships with participant GPA and the Barona estimate of intellectual functioning (($r(62) = .370$; 95% CI [0.137, 0.564]) and ($r(62) = .478$; 95% CI [0.263, 0.648]), respectively).

The tactile figure exploration task scored at the eight-minute time interval demonstrated positive relationships with all of the WAIS-IV subtests included in the analysis. In addition, the tactile figure exploration subtest displayed positive correlations with participant GPA and the Barona estimate of intellectual functioning.

Tactile matching phase one scored at the three-minute time interval demonstrated positive correlations with the digit span, arithmetic, and vocabulary subtests of the WAIS-IV. It did not produce a relationship with the similarities or information subtests. This lack of a relationship might not be indicative of a lack of convergent validity as tactile matching was designed to capture performance related abilities such as fluid intelligence, cognitive processing speed, and short-term memory, and the information and

similarities subtests were designed to capture verbal reasoning ability, long-term memory, and crystallized intelligence. However, one might find relationships with a larger sample size because all of the tasks mentioned were theoretically capturing aspects of overall *g*. This lack of a relationship might indicate the tactile matching task required further refinement. Tactile matching phase one displayed positive correlations with the Barona estimate of intelligence, but not participant GPA.

Further investigation revealed tactile matching phase two scored at the three-minute time interval produced positive correlations with the digit span and vocabulary subtests. It did not produce relationships with similarities, arithmetic, or information. This finding was not surprising as tactile matching was designed to capture mostly fluid intelligence and cognitive processing speed, but the researcher was expecting it to capture limited aspects of short-term memory, which would have been supported by a correlation with the arithmetic subtest. Tactile matching phase two did not demonstrate a relationship with participant GPA, but Laidra et al. (2007) indicated only a weak relationship between intelligence and GPA. Tactile matching phase two did demonstrate a moderate, positive correlation with the Barona estimate of intelligence. Tactile matching phase two appears to be the weakest of all aspects of the TAP in terms of ability to capture overall *g*.

In addition, tactile matching phase one and two combined scored at the three-minute interval demonstrated positive correlations with digit span, vocabulary, and arithmetic. It did not correlate with the similarities or information subtests, but likely for the same reasons mentioned in the two previous paragraphs. Tactile matching did not correlate with participant GPA, but this was likely due to the previously mentioned weak relationship between GPA and intelligence and the overall weakness of tactile matching

phase two. Tactile matching phase one and two combined demonstrated a moderate, positive correlation with the Barona estimate of intelligence.

The tactile figure-ground identification task scored using the D2 method suggested positive correlations with the digit span, vocabulary, arithmetic, and information subtests. It did not demonstrate a relationship when correlated with the similarities subtest. This was likely because tactile figure-ground identification was designed to capture performance related abilities such as fluid intelligence, cognitive processing speed, and short-term memory and the similarities subtest was designed to capture verbal reasoning ability, long-term memory, and crystallized intelligence. Tactile figure-ground identification failed to correlate with participant GPA; however, this may be due to the weak relationship between GPA and intelligence, as previously mentioned. Tactile figure-ground identification did demonstrate a positive correlation with the Barona estimate of intelligence.

The tactile block configurations subtest scored using the D1 method produced positive relationships when correlated with the similarities, digit span, vocabulary, arithmetic, and information subtests of the WAIS-IV. It did not demonstrate a relationship with participant GPA, likely for the reasons previously mentioned. Tactile block configurations displayed a positive correlation with the Barona estimate of intelligence.

The divergent validity of the TAP was investigated by examining heterotrait-heteromethod blocks, specifically the relationships among the TAP subtests and the achievement striving and conscientiousness measures. The achievement striving and conscientiousness measures were selected for this because Moutafi et al. (2003) indicated

there might be a negative relationship between conscientiousness and verbal intelligence, but performance intelligence had not demonstrated a relationship with conscientiousness. Furnham et al. (2003) indicated that achievement striving might not be positively correlated with verbal intellectual abilities and there should not be a correlation between achievement striving and performance-based intelligence measures. Pearson's *r* was utilized to discern the presence of relationships between the aforementioned measures. Results failed to demonstrate any type of correlation between any of the TAP subtests and the achievement striving and conscientiousness measures (See Table 40).

Table 40

Multitrait-Multimethod Matrix

	SI	DS	VC	AR	IN	TTD	TFE	TM1	TM2	TM1&2	TFGd2	TBCd1	ACH	CON	GPA
SI	(.79)														
DS	.415	(.85)													
VC	.697	.586	(.86)												
AR	.371	.461	.480	(.79)											
IN	.503	.328	.637	.536	(.88)										
TTD	.292	.385	.401	.368	.311	(.72)									
TFE	.251	.567	.379	.469	.325	.562	...								
TM1	.174	.423	.326	.425	.214	.612	.734	...							
TM2	.029	.355	.262	.226	.063	.456	.617	.802	...						
TM1&2	.105	.409	.309	.340	.144	.560	.710	.947	.952	...					
TFGd2	.130	.483	.412	.321	.299	.666	.519	.633	.713	.710	(.57)				
TBCd1	.501	.418	.476	.380	.368	.577	.511	.429	.334	.400	.548	(.59)			
ACH	.101	.196	-.134	-.047	-.088	.077	.201	-.027	-.109	-.072	-.089	.116	(.77)		
CON	-.092	-.037	-.182	-.078	-.212	-.016	.090	.053	.010	.033	-.080	-.014	.655	(.76)	
GPA	.306	.270	.248	.282	.316	.370	.400	.237	.185	.221	0.207	.247	.270	.096	...
BAR	.339	.461	.478	.347	.487	.478	.568	.551	.419	.509	.395	.377	.082	-.048	.376

Note: $N = 64$, SI = Similarities, DS = Digit Span, VC = Vocabulary, AR = Arithmetic, IN = Information, TTD = Tactile Tile Design with time limits set at 90 and 180-seconds, TFE = Tactile Figure Exploration at eight-minutes, TM1 = Tactile Matching phase one at three-minutes, TM2 = Tactile Matching phase two at three-minutes, TM1&2 = Tactile Matching phase one and two combined, TFGd2 = Tactile Figure-Ground Identification using the D2 scoring method, TBCd1 = Tactile Block Configuration using the D1 scoring method, ACH = Achievement Striving, CON = Conscientiousness, GPA = participant grade point average, BAR = the Barona estimate of intelligence

Multitrait-Multimethod Matrix of Participants Who Were Blind

A modified MTMM was also constructed for participants who were blind. The reliability of the TAP as well as the WAIS-IV subtests, achievement striving, and conscientiousness measures were calculated as part of the modified MTMM for participants who were blind. When considering the monotrait-monomethod blocks, the WAIS-IV subtests demonstrated good split-half reliabilities; specifically all were at or above .84. The tactile tile design task of the TAP demonstrated a split-half reliability of .77, which was considered acceptable, according to Nunnally and Bernstein (1994). The tactile figure-ground identification task and tactile block configurations tasks suggested low split-half reliability by producing figures of .55 and .60, respectively. The researcher was unable to calculate reliability coefficients for tactile figure exploration and tactile matching as they would require test-retest reliability and test-retest would be the preferred reliability, as previously mentioned. The achievement striving and conscientiousness measures displayed acceptable Cronbach's α figures of .79 and .78, according to Nunnally and Bernstein. The reliability of participant GPA and the Barona estimate of intelligence could not be calculated.

The convergent validity of the TAP was investigated by examining the monotrait-heteromethod blocks, specifically the relationship between the TAP, WAIS-IV subtests that could be completed by participants who were blind, participant GPA, and the Barona estimate of intellectual functioning. The tactile tile design task scored with time limits set at 90 and 180-seconds produced positive correlation with similarities, vocabulary, and arithmetic. It failed to demonstrate correlations with digit span and information. This was not surprising as tactile tile design was constructed with the intention to capture mostly

fluid intelligence and cognitive processing speed while digit span and information do not focus on those abilities. However, the researcher expected a correlation between the subtests due to all theoretically capturing some aspects of overall *g*. Further, tactile tile design demonstrated a positive relationships with the Barona estimate of intellectual functioning, but not participant GPA, likely again due to the weak relationship between GPA and intelligence.

The tactile figure exploration task scored at the eight-minute time interval demonstrated positive relationships with all of the WAIS-IV subtests included in the analysis. In addition, the tactile figure exploration subtest displayed positive correlations with participant GPA and the Barona estimate of intellectual functioning.

Investigation of tactile matching phase one scored at the three-minute time interval demonstrated positive correlations with the digit span, arithmetic, and vocabulary subtests of the WAIS-IV. It did not produce correlations with the similarities or information subtests. This lack of a relationship was likely due to tactile matching being designed to capture performance related abilities such as fluid intelligence, cognitive processing speed, and short-term memory and the information and similarities subtests were designed to capture verbal reasoning ability, long-term memory, and crystallized intelligence. Tactile matching phase one displayed positive correlations with the Barona estimate of intelligence, but not participant GPA.

Further analyses suggested tactile matching phase two scored at the three-minute time interval produced no correlations with any WAIS-IV subtests. This was somewhat surprising, but might be due in part to a small sample size. Tactile matching phase two did not demonstrate a significant relationship with participant GPA. Tactile matching

phase two did not demonstrate a correlation with the Barona estimate of intelligence when completed by participants who were blind.

Tactile matching phase one and two combined scored at the three-minute interval demonstrated a positive correlation with arithmetic. It did not correlate with the similarities, digit span, vocabulary, or information subtests, likely for the same reasons mentioned in previous paragraphs (i.e., low sample size and differences in the abilities the tasks were designed to capture). Tactile matching did not correlate with participant GPA. Tactile matching phase one and two combined demonstrated a moderate, positive correlation with the Barona estimate of intelligence.

The tactile figure-ground identification task scored using the D2 method produced positive correlations with the digit span, vocabulary, and arithmetic subtests. It did not demonstrate a relationship when correlated with the similarities or information subtests, but this was likely due to the differences in the types of abilities the subtests were intended to capture. Tactile figure-ground identification failed to correlate with participant GPA. Tactile figure-ground identification failed to demonstrate a correlation with the Barona estimate of intelligence, but this might be due to low sample size.

The tactile block configurations subtest scored using the D1 method produced positive relationships when correlated with the similarities, digit span, vocabulary, and arithmetic subtests of the WAIS-IV. It did not demonstrate a relationship with the information subtest and participant GPA, likely for the reasons previously mentioned. Tactile block configuration displayed a positive correlation with the Barona estimate of intelligence.

The divergent validity of the TAP was investigated by examining the heterotrait-heteromethod blocks, specifically the relationship between the TAP subtests and the achievement striving and conscientiousness measures completed by participants who were blind. Pearson's *r* was utilized to investigate the potential presence of relationships among the aforementioned measures. Results failed to demonstrate any type of correlation between any of the TAP subtests and the achievement striving and conscientiousness measures in participants who were blind (See Table 41).

Table 41

MTMM for Participants Who Were Blind

	SI	DS	VC	AR	IN	TTD	TFE	TM1	TM2	TM1&2	TFGd2	TBCd1	ACH	CON	GPA
SI	(.84)														
DS	.590	(.89)													
VC	.758	.669	(.91)												
AR	.402	.420	.530	(.85)											
IN	.473	.360	.669	.588	(.90)										
TTD	.411	.325	.402	.471	.299	(.77)									
TFE	.381	.486	.500	.564	.397	.602	...								
TM1	.311	.355	.399	.598	.306	.744	.625	...							
TM2	.084	.231	.243	.265	.055	.515	.513	.721	...						
TM1&2	.210	.314	.344	.461	.192	.675	.612	.924	.931	...					
TFGd2	.193	.385	.394	.409	.320	.578	.486	.714	.750	.789	(.55)				
TBCd1	.507	.411	.436	.485	.325	.593	.633	.627	.498	.605	.576	(.60)			
ACH	.002	.045	-.297	-.123	-.141	.018	.194	-.121	-.269	-.212	-.313	.048	(.79)		
CON	-.058	-.216	-.350	-.115	-.125	.021	.134	-.020	-.217	-.130	-.294	.102	.696	(.78)	
GPA	.278	.207	.212	.344	.351	.325	.481	.192	.134	.174	.011	.233	.242	.030	...
BAR	.510	.424	.611	.436	.567	.428	.517	.432	.326	.408	.312	.408	.021	-.145	.429

Note: $n = 32$, SI = Similarities, DS = Digit Span, VC = Vocabulary, AR = Arithmetic, IN = Information, TTD = Tactile Tile Design with time limits set at 90 and 180-seconds, TFE = Tactile Figure Exploration at eight-minutes, TM1 = Tactile Matching phase one at three-minutes, TM2 = Tactile Matching phase two at three-minutes, TM1&2 = Tactile Matching phase one and two combined, TFGd2 = Tactile Figure-Ground Identification using the D2 scoring method, TBCd1 = Tactile Block Configuration using the D1 scoring method, ACH = Achievement Striving, CON = Conscientiousness, GPA = participant grade point average, BAR = the Barona estimate of intelligence

Multitrait-Multimethod Matrix of Participants Who Were Sighted

Another modified MTMM was constructed for participants who were sighted. The reliability of the TAP as well as the WAIS-IV subtests, achievement striving, and conscientiousness measures were calculated as part of the monotrait-monomethod blocks of the modified MTMM for participants who were sighted. The similarities subtest displayed a low split-half reliability of .66. According to Nunnally and Bernstein's (1994) guidelines for interpreting reliability, digit span demonstrated an acceptable split-half reliability of .77. The vocabulary task demonstrated a low split half reliability figure of .63. Arithmetic demonstrated a poor split-half reliability figure of .50, as indicated by Nunnally and Bernstein. The information subtest displayed a strong split-half reliability of .82, as indicated by Nunnally and Bernstein. The tactile tile design task of the TAP demonstrated a split-half reliability of .67, which was considered to be below acceptable. The tactile figure-ground identification task exhibited a low split-half reliability figure of .66. The tactile block configuration task demonstrated a low split-half reliability by producing a figure of .57. The researcher was unable to calculate reliability coefficients for tactile figure exploration and tactile matching as they would require test-retest reliability. The achievement striving and conscientiousness measures displayed acceptable Cronbach's α figures of .75 and .74, respectively. The reliability of participant GPA and the Barona estimate of intelligence could not be calculated.

The convergent validity of the TAP was investigated by examining the monotrait-heteromethod blocks, specifically the relationships among the TAP, WAIS-IV subtests, participant GPA, and the Barona estimate of intellectual functioning. The tactile tile design task scored with time limits set at 90 and 180-seconds produced positive

correlations with digit span, vocabulary, and arithmetic. It failed to demonstrate relationships with similarities and information. This was not surprising as tactile tile design was constructed with the intention to capture mostly fluid intelligence and cognitive processing speed while similarities and information do not intend to capture those abilities. Tactile tile design demonstrated positive relationships with the Barona estimate of intellectual functioning and participant GPA.

The tactile figure exploration task scored at the eight-minute time interval demonstrated positive relationships with the digit span subtest. It did not demonstrate correlations with similarities, vocabulary, arithmetic, and information. The tactile figure exploration task appeared to be a source of great difficulty for many participants who were sighted. Many of the participants who were sighted required more than twenty-minutes to complete the entire task. Several participants described it as the least favorite task and the most difficult to complete. The novel nature of this task may have made it difficult for sighted participants to adjust and complete it successfully. In addition, the tactile figure exploration subtest failed to display relationships with participant GPA and the Barona estimate of intellectual functioning in participants who were sighted.

Tactile matching phase one scored at the three-minute time interval demonstrated positive correlations with the digit span and vocabulary subtests of the WAIS-IV. It did not produce correlations with the similarities, arithmetic, or information subtests. This lack of a relationship might be due to a combination of the subtests being designed to capture different abilities and low sample size. Tactile matching phase one failed to display correlations with the Barona estimate of intelligence and participant GPA.

Additional investigation revealed tactile matching phase two scored at the three-minute time interval produced positive correlations with the digit span and vocabulary subtests of the WAIS-IV. It did not correlate with similarities, arithmetic, or information. Tactile matching phase two did not demonstrate a relationship with participant GPA. Tactile matching phase two did not demonstrate a correlation with the Barona estimate of intelligence when completed by participants who were sighted.

Further analyses suggested tactile matching phase one and two combined scored at the three-minute interval demonstrated a positive correlation with digit span and vocabulary. It did not correlate with the similarities, arithmetic, or information subtests, but likely for the same reasons mentioned in previous paragraphs. Tactile matching did not correlate with participant GPA or the Barona estimate of intelligence.

The tactile figure-ground identification task scored using the D2 method produced positive correlations with the digit span and vocabulary subtests. It did not demonstrate a relationship when correlated with the similarities, arithmetic, or information subtests, but this was likely due to the differences in the types of abilities the subtests were intended to capture or low sample size. Tactile figure-ground identification failed to correlate with participant GPA. Tactile figure-ground identification demonstrated a correlation with the Barona estimate of intelligence.

The tactile block configurations subtest scored using the D1 method produced positive relationships when correlated with the similarities, digit span, vocabulary, and information subtests of the WAIS-IV. It did not demonstrate a relationship with the arithmetic subtest. This was likely due to tactile block configurations being designed to focus primarily on fluid intelligence and cognitive processing speed. It did not display a

relationship when correlated with participant GPA. Tactile block configurations displayed a positive correlation with the Barona estimate of intelligence.

The divergent validity of the TAP was investigated by examining the heterotrait-heteromethod blocks, specifically the relationship between the TAP subtests and the achievement striving and conscientiousness measures completed by participants who were sighted. Pearson's *r* was utilized to investigate the potential presence of relationships between the aforementioned measures. Results failed to demonstrate any type of correlations among any of the TAP subtests and the achievement striving and conscientiousness measures in participants who were sighted (See Table 42).

Table 42

MTMM for Participants Who Were Sighted

	SI	DS	VC	AR	IN	TTD	TFE	TM1	TM2	TM1&2	TFGd2	TBCd1	ACH	CON	GPA
SI	(.66)														
DS	.124	(.77)													
VC	.566	.470	(.63)												
AR	.307	.578	.348	(.50)											
IN	.563	.300	.569	.418	(.82)										
TTD	.124	.398	.455	.143	.375	(.67)									
TFE	.085	.661	.266	.293	.321	.380	...								
TM1	.054	.437	.465	.162	.229	.337	.722	...							
TM2	-.026	.403	.453	.150	.138	.219	.508	.738	...						
TM1&2	.009	.448	.491	.167	.190	.289	.644	.913	.949	...					
TFGd2	.085	.555	.527	.231	.333	.730	.484	.540	.661	.652	(.66)				
TBCd1	.500	.436	.565	.171	.448	.576	.420	.303	.173	.246	.555	(.57)			
ACH	.249	.351	.106	.062	-.014	.086	.134	-.135	-.116	-.133	.028	.188	(.75)		
CON	-.144	.158	.089	-.035	-.348	-.128	-.090	.003	.170	.104	.052	-.169	.614	(.74)	
GPA	.361*	.281	.317	.185	.290	.369	.210	.131	.087	.114	.300	.258	.261	.136	...
BAR	.103	.422	.373	.112	.541	.433	.304	.284	.086	.185	.377*	.419	.048	-.048	.213

Note: $n = 32$, SI = similarities DS = Digit Span, VC = Vocabulary, AR = Arithmetic, IN = Information, TTD = Tactile Tile Design with time limits set at 90 and 180-seconds, TFE = Tactile Figure Exploration at eight-minutes, TM1 = Tactile Matching phase one at three-minutes, TM2 = Tactile Matching phase two at three-minutes, TM1&2 = Tactile Matching phase one and two combined, TFGd2 = Tactile Figure-Ground Identification using the D2 scoring method, TBCd1 = Tactile Block Configuration using the D1 scoring method, ACH = Achievement Striving, CON = Conscientiousness, GPA = participant grade point average, BAR = the Barona estimate of intelligence

Hypotheses

H_1 predicted positive correlations among the PRI and PSI of the WAIS-IV and the TAP subtests when completed by individuals who were sighted. All five of the TAP subtests demonstrated positive relationships with the WAIS-IV PRI and the subtests that comprise the index. The PRI primarily measured fluid intelligence, but also captured short-term memory functioning. The positive relationships indicated the PRI and the TAP were capturing similar constructs of intelligence. The relationships were weak to moderate, which indicates there was overlap, but not a strong relationship between the two measures.

H_1 also predicted relationships among the PSI and the subtests of the TAP. Three of the five TAP subtests did demonstrate positive correlations with the PSI. Another showed a trend toward a relationship that might change with a larger sample size. Only the PSI and tactile block configurations tasks failed to demonstrate any type of relationship. One possible explanation for this was that the participants who were sighted may have been disoriented by the novel nature of the TAP and the loss of vision, as all participants who were sighted completed the TAP while wearing a blindfold. Previous research suggested that when a participant who was sighted was blindfolded he or she experienced a sense of disorientation and did not perform as well on nonvisual tasks as a person who was blind (e.g., Boven et al., 2000; Heller, Calcaterra, Burson, & Tyler, 1996; Roder, Rosler, & Spence, 2004; Sathian, 2000).

H_2 called for positive correlations among the WAIS-IV subtests block design, matrix reasoning, symbol search, visual puzzles, and coding and the TAP subtests in participants who were sighted. The TAP subtests demonstrated positive relationships

with the block design subtest, which suggested the TAP was capturing aspects of fluid intelligence. The correlations among tactile figure exploration, tactile matching, and symbol search suggested the TAP subtests were capturing aspects of cognitive processing speed. This idea was further strengthened by the positive relationship between tactile figure exploration, tactile matching, and coding. However, there were no relationships between the TAP and the matrix reasoning and visual puzzles tasks. This could be due to the aforementioned reason regarding the novel nature of the TAP and disorientation of individuals who were sighted (e.g., Boven et al., 2000; Heller et al., 1996; Roder et al., 2004; Sathian, 2000). Further, this lack of correlation could also be due to the matrix reasoning task lacking any sort of time constraint while all of the TAP subtests have some type of time constraint.

H_3 expected that scores on the WAIS-IV VCI and WMI would correlate positively with scores on TAP subtests when completed by individuals who were blind. The Psychological Corporation (2008) reported that the VCI of the WAIS-IV demonstrated the strongest relationship of any index when correlating index scores and *g*. Hence, though the verbal subtests of the WAIS-IV captured different CHC abilities than the TAP subtests, the researcher expected relationships among the TAP and the VCI because both were capturing aspects of *g*. Results supported this idea. All of the TAP subtests except tactile figure-ground identification demonstrated positive relationships when correlated with the VCI. The trend toward a relationship displayed by tactile figure-ground identification would likely become truly significant with a larger sample size.

The TAP subtests demonstrated positive relationships when correlated with the WMI, with the exception of tactile matching phase two. The Psychological Corporation

(2008) reported that the WMI of the WAIS-IV captured aspects of the CHC ability termed short-term memory. Given the relationships among the WMI and most of the TAP subtests, it appeared that the TAP was capturing aspects of the CHC ability short-term memory. Though the tactile matching phase two task did not demonstrate a relationship with the WMI, it was important to remember that the tactile matching task was designed primarily to capture cognitive processing speed, thus it does not seem unreasonable that the two did not correlate. However, it was also worth noting that the tactile matching phase two task consistently demonstrated lower correlation coefficients that the tactile matching phase one task. One reason for this may have been that participants had the opportunity to practice finding the target shape for tactile matching phase one, but not for phase two. In future research, it may be beneficial to allow participants to practice finding the target shape in phase two of tactile matching.

H_4 predicted scores on the WAIS-IV similarities, digit span, vocabulary, arithmetic, and information would correlate positively with scores on TAP subtests when completed by individuals who were blind. Though the vocabulary, similarities, and information subtest of the WAIS-IV capture different CHC abilities than the TAP subtests, many positive relationships were found, which were likely due to the TAP and WAIS-IV subtests tapping into overall *g*. The TAP subtests demonstrated positive relationships with digit span and arithmetic, with the exception of tactile tile design and tactile matching phase two. Tactile tile design displayed a trend toward a relationship with the digit span task that likely would be more meaningful with a larger sample size. Tactile matching phase two may have demonstrated a lack of relationships due to the lack

of a practice opportunity for participants to learn the new target shape, but further research is required fully investigate this possibility.

H_5 called for scores on measures of conscientiousness and achievement striving to demonstrate no correlations with all participant performance on TAP subtests. The subtests of the TAP did not correlate with the achievement striving and conscientiousness measures, which supports the divergent validity of the TAP. Weak, positive correlations were found between GPA, tactile tile design, tactile figure exploration, and tactile matching. The tactile figure-ground identification and tactile block configuration tasks did not correlate with GPA. Laidra et al. (2007) found a significant, positive relationship between intelligence and GPA, but did not use a Wechsler instrument in their research. Further, Laidra et al. made use of a measure that did not apply time constraints to participants and both the tactile figure-ground identification and tactile block configuration tasks relied heavily on time constraints. This difference in the approach to measuring intelligence might account for the relationships between GPA and the TAP subtests.

Other Findings

The information gathered regarding the nonvisual, tactile performance of participants appeared to suggest differences based on participant group. Specifically, it appeared as though the performance of individuals who were blind peaked on the tactile matching task at between two and three-minutes, but near the five-minute mark participants who were sighted closed the gap between scores of the two groups. However, it does not appear that time constraints were the most important factor in successfully completing the TAP. When considering participants who were sighted, performance on

the tactile figure exploration task improved up to the ten-minute mark, but after that point more time did not appear to lead to higher scores. These findings might suggest that the TAP was capturing abilities beyond how a person functions under a time constraint.

Further, though much of the data were correlational in nature it was worth noting the TAP did not correlate with every measure. None of the TAP subtests demonstrated a relationship with achievement striving or conscientiousness. This supported to the usefulness of the TAP in the form of discriminant validity. The TAP subtests displayed relationships with the performance-based subtests of the WAIS-IV, which added further support to the usefulness of the TAP in the form of convergent validity. It was worth noting that in the overall sample scores, each subtest of the TAP demonstrated a positive relationship with the WAIS-IV vocabulary subtest. Though the performance-based tasks of the TAP might seem unrelated to vocabulary, one must also consider that the Psychological Corporation (2008) reported the vocabulary subtest possessed the strongest relationship to overall *g* of any of the WAIS-IV subtests. Hence, the relationship between the TAP subtests and the WAIS-IV vocabulary subtest might be indicative of the TAP subtest's relationship to overall *g*.

Based on the correlations found among length of experience as a person who was blind as well as length of experience as a person who was sighted on performance on TAP subtests as well as other findings mentioned, the TAP appeared to be capturing aspects of the intellectual abilities Spearman described in 1904, as well as the tactile abilities Gardner described in 2004. Those tactile abilities illustrated a positive relationship with CHC intellectual abilities as measured by the WAIS-IV in the current sample. While there appeared to be overlap between the abilities the TAP captured and

the abilities the WAIS-IV captured, there was a possibility of the TAP measuring abilities the WAIS-IV was simply not designed to gauge; however, additional research was required to further investigate that prospect.

Limitations and Future Directions

This study was designed to examine the validity and potential usefulness of the TAP in assessing performance-based intellectual abilities of individuals who were blind. However, it was not administered exclusively to individuals who were blind. In an effort to further determine the potential validity of the TAP, individuals who were sighted were included in the research project as well. Ultimately this inclusion served to further provide evidence in favor of the usefulness of the TAP. However, the current research endeavor was best viewed as the first step in a long journey.

The current study included sixty-four participants, of which thirty-two were individuals who were blind. While this number was reasonable when considering that one goal of the current project was to assess the most basic administration issues and potential problems in the use of a nonvisual, tactile measure of performance, it should not be viewed as a full normatization sample. A proper normatization sample might require a few hundred participants who were blind. Given the nature of the TAP administration procedure (i.e., one-on-one and requiring approximately ninety-minutes for some participants), the collection of data would be time consuming and costly.

However, the community of individuals who were blind had been open, receptive, and helpful throughout the entire data collection procedure. Several participants who were blind reported they had undergone a previous psychological testing experience that felt awkward or as though the measure were not suited to him or her or capturing his or

her full potential. The majority of participants who were blind reported they enjoyed the challenging nature of the TAP and appreciated the researcher's efforts in making intellectual assessment more accessible to all persons. However, the participants who were sighted did not seem to enjoy the data collection procedure to the extent the participants who were blind reported.

Participants who were sighted reported greater difficulty completing the TAP than participants who were blind, and data were indicative of that difficulty. Participants who were sighted often verbalized concern regarding performance on TAP subtests and appeared to double or triple check work on several items. This great concern or obsessiveness resulted in participants who were sighted requiring more time to finish TAP subtests (e.g., a handful of participants who were sighted required more than thirty-minutes to complete the tactile figure exploration task). This was likely due to the novel situation participants who were sighted were thrust into, without having time to adjust to the loss of one of their primary senses.

In the current study, participants who were sighted were not allowed an opportunity to adjust to the loss of vision. This abrupt change forced participants to rely on nonvisual, tactile processing abilities which he or she likely did not normally use. Heller et al. (1996) suggested that when a person who was sighted was blindfolded he or she would require approximately one hour of time to adjust to his or her new sensory experience. For the current study, participants who were sighted did not have access to any adjustment period.

The data collection procedure for the current study required between three and four hours of time to complete for participants who were sighted. Requiring an additional

hour of time to the data collection procedure did not appear to be a feasible option. Hence, the researcher believed it best to not allow any adjustment period for any participant and treat the adjustment to the novel situation as a constant. This decision likely contributed to the difference in performance between participants who were blind and participants who were sighted. Future research is needed to investigate the possible influence on TAP scores of an adjustment period for participants who were sighted. To avoid any potential influence of fatigue, the possibility of altering the data collection procedure to take place over the course of two sessions should be investigated.

Specifically, participants who were sighted might be asked to complete the WAIS-IV one day and the TAP with an adjustment period to allow for the participant to recover from the shock of losing his or her vision on another day. Implementing this type of data collection procedure would increase the possibility of participant attrition, but might also help participants who were sighted adjust to the demands of the TAP more quickly. An adjustment period might serve to help a participant who was sighted become more comfortable with the nonvisual nature of the TAP and bring his or her performance on par with a participant who was blind. This change in the data collection procedure might allow for more meaningful comparisons of participant performance and further investigation of the abilities captured by the TAP and WAIS-IV.

An additional change to the administration procedure of the tactile matching task might provide an opportunity to better capture participant abilities. Specifically, tactile matching phase two did not allow for a practice procedure in this incarnation of the TAP. Results indicated participants performed at a lower level on tactile matching phase two as compared to phase one. Tactile matching phase one allowed participants to practice

finding the target shape and adjust to the novel nature of the task, but phase two did not allow for such and immediately launched the participant into the new task. Future research should include a practice phase for phase two of the tactile matching procedure and investigate the potential differences in participant performance on phase one and phase two of the tactile matching task.

The item difficulty of the TAP subtests was also a potential limitation of the current research endeavor. One of the distinguishing features of the WAIS-IV was the difficulty of items toward the end of any given subtest. Specifically, The Psychological Corporation (2008) reported the WAIS-IV was designed so only a few participants would complete the final items on a subtest. The TAP was designed with accessibility in mind as the primary objective. The researcher appeared to have accomplished this goal; however, difficulty of items might have been overlooked. The TAP would likely benefit from more, difficult items for every subtest. The lack of difficult items might explain some of the weak correlations between the TAP and WAIS-IV subtests.

Conclusions

The original intent behind the creation of the TAP was to produce a measure capable of capturing performance-based CHC abilities. Based on these results, it appeared that the TAP and performance-based subtests of the WAIS-IV were capturing similar abilities. However, further research is required to determine the exact nature of those abilities and refine the data collection procedure. Through the use of a modified MTMM, the TAP demonstrated divergent and convergent validity, which contributed to its overall construct validity. Though more research is required, the TAP demonstrated considerable promise as a nonvisual measure of CHC abilities.

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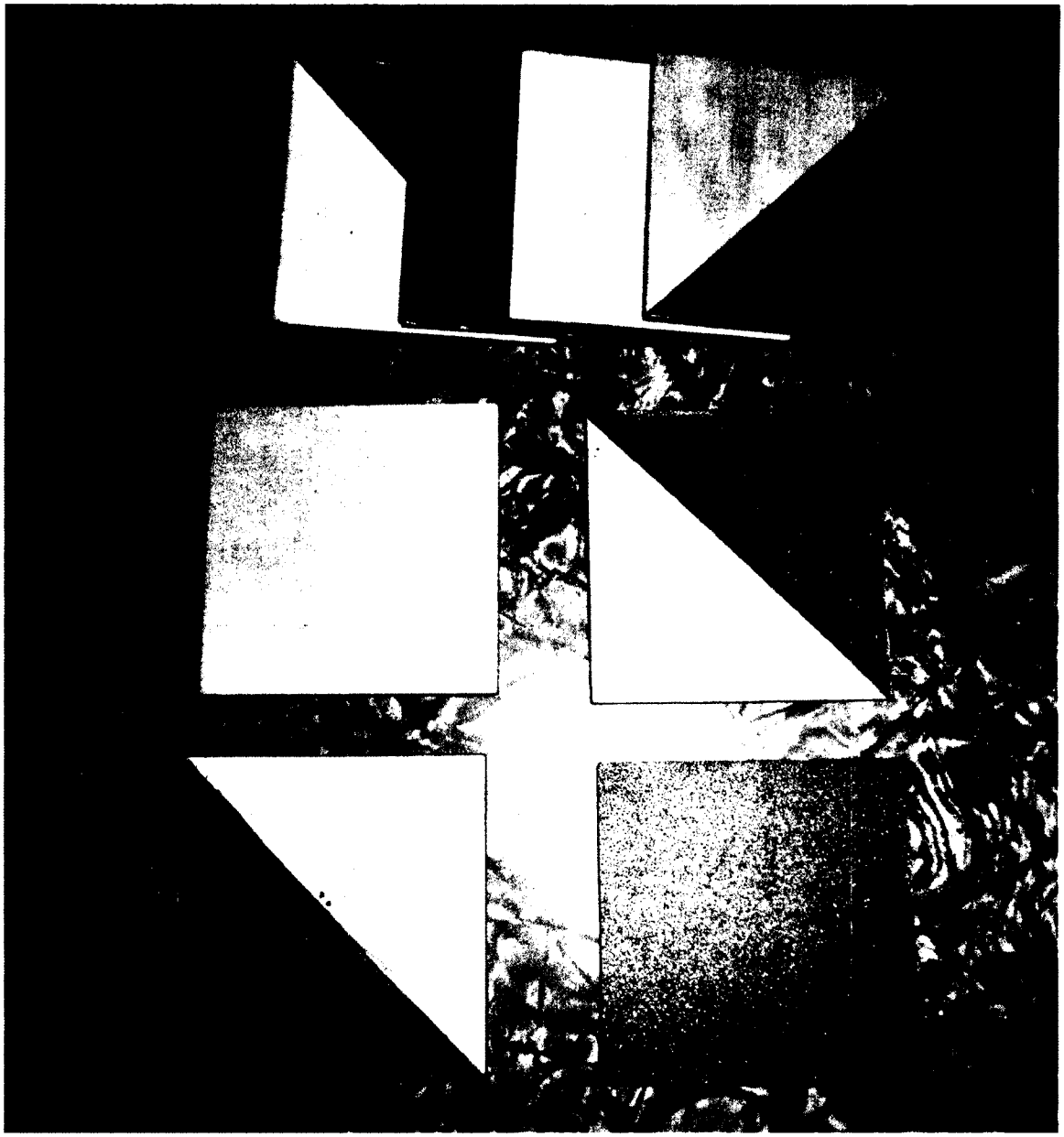
APPENDIX A

TACTILE TILE DESIGN



Tactile Tile Design

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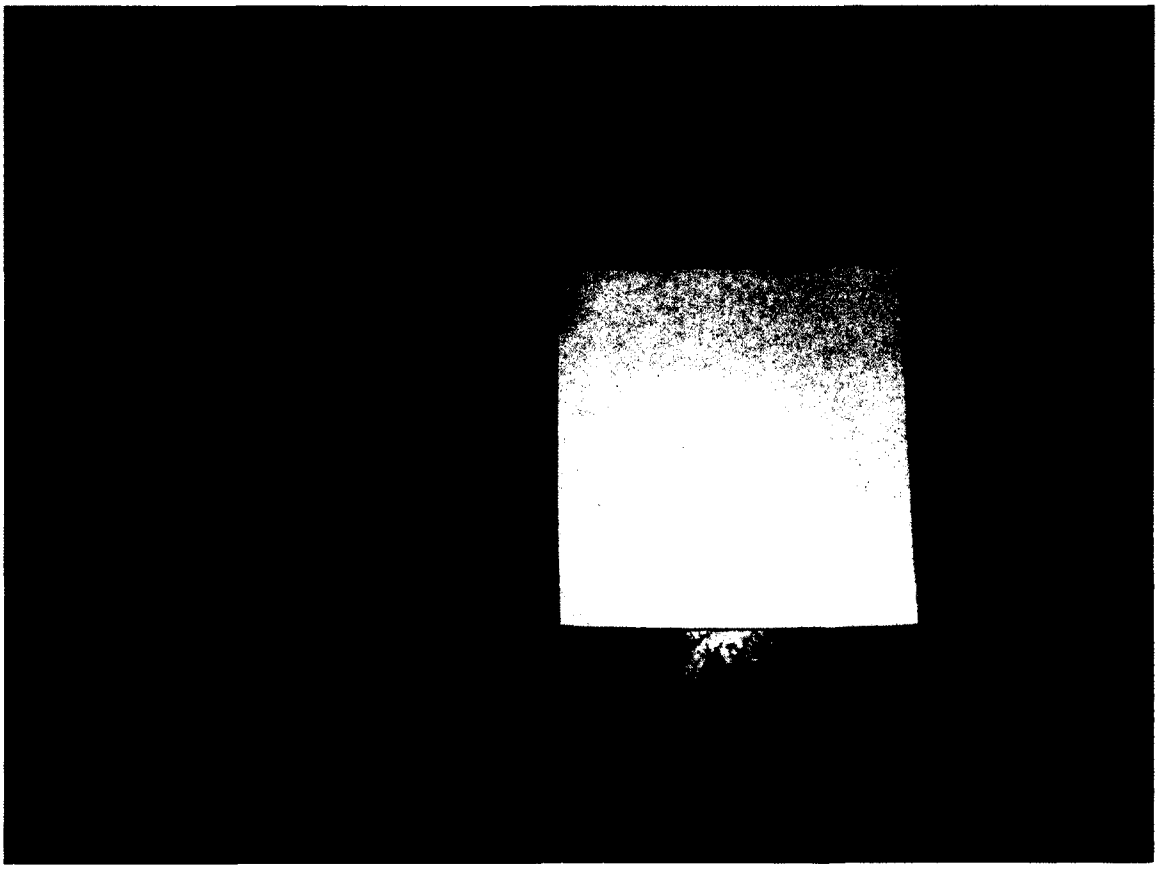

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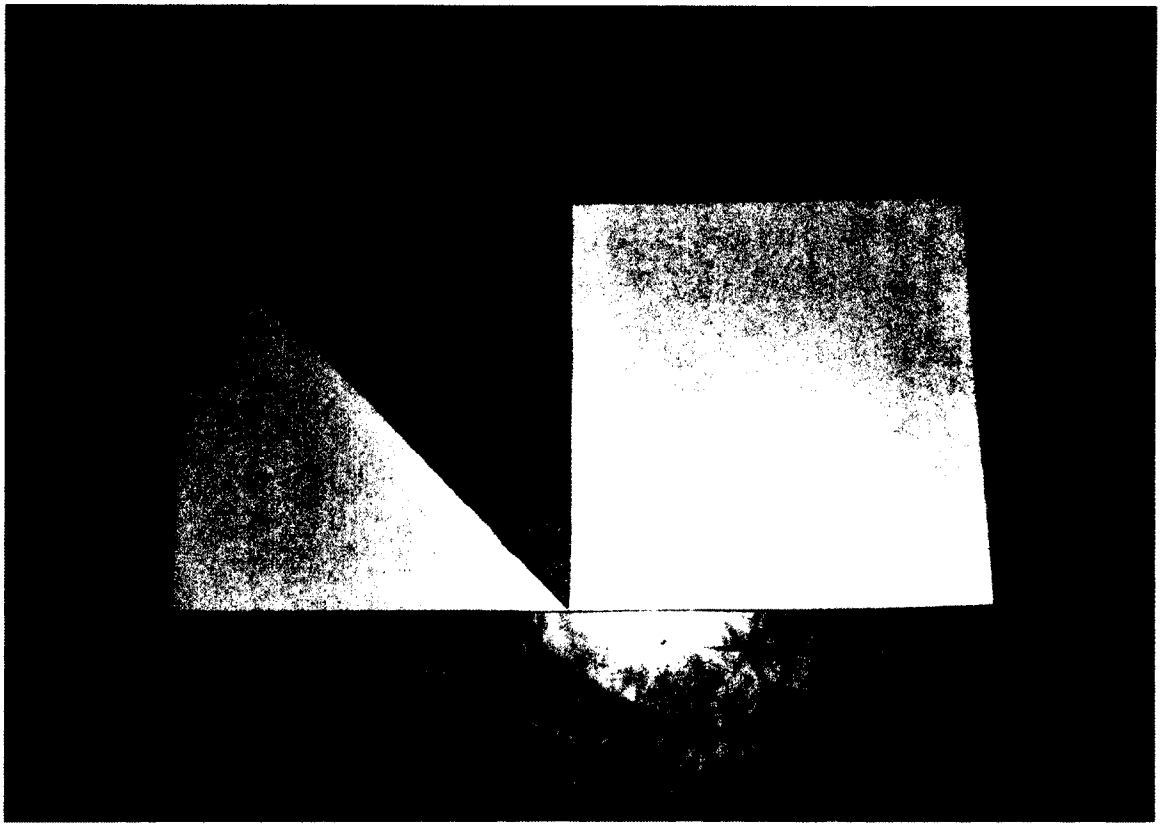

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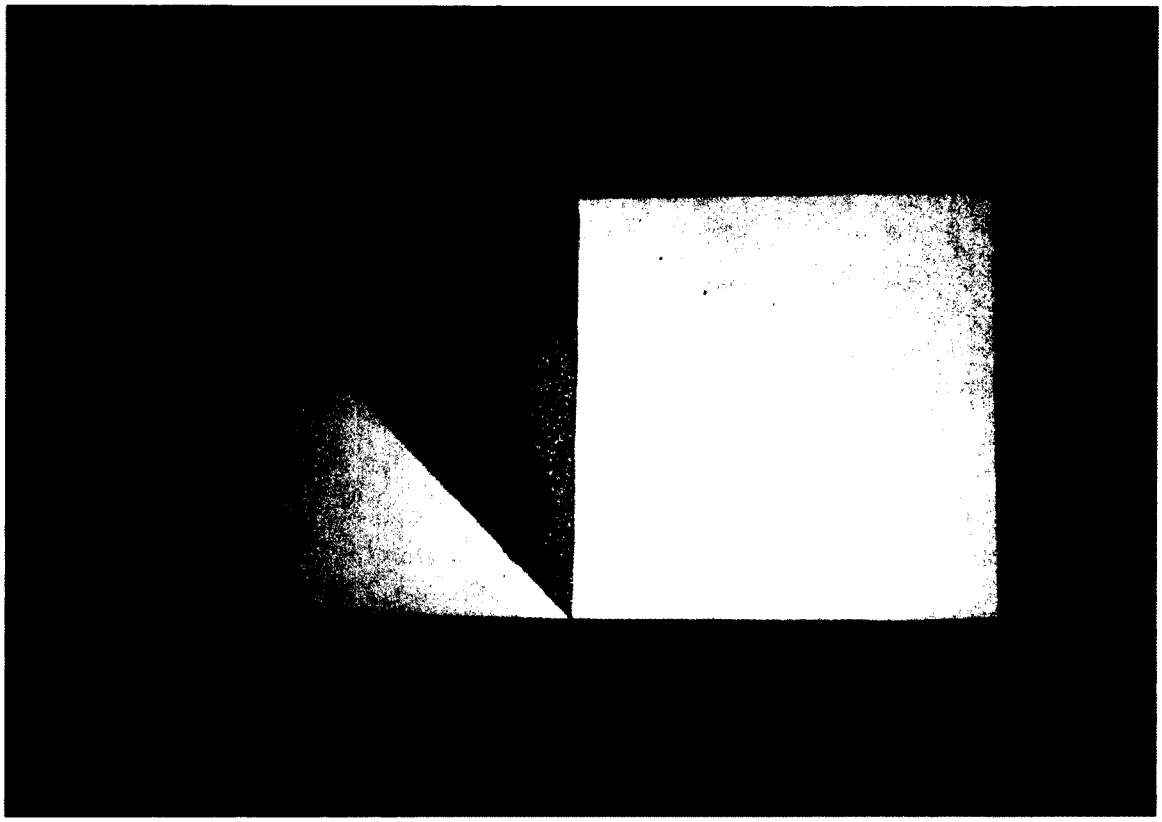

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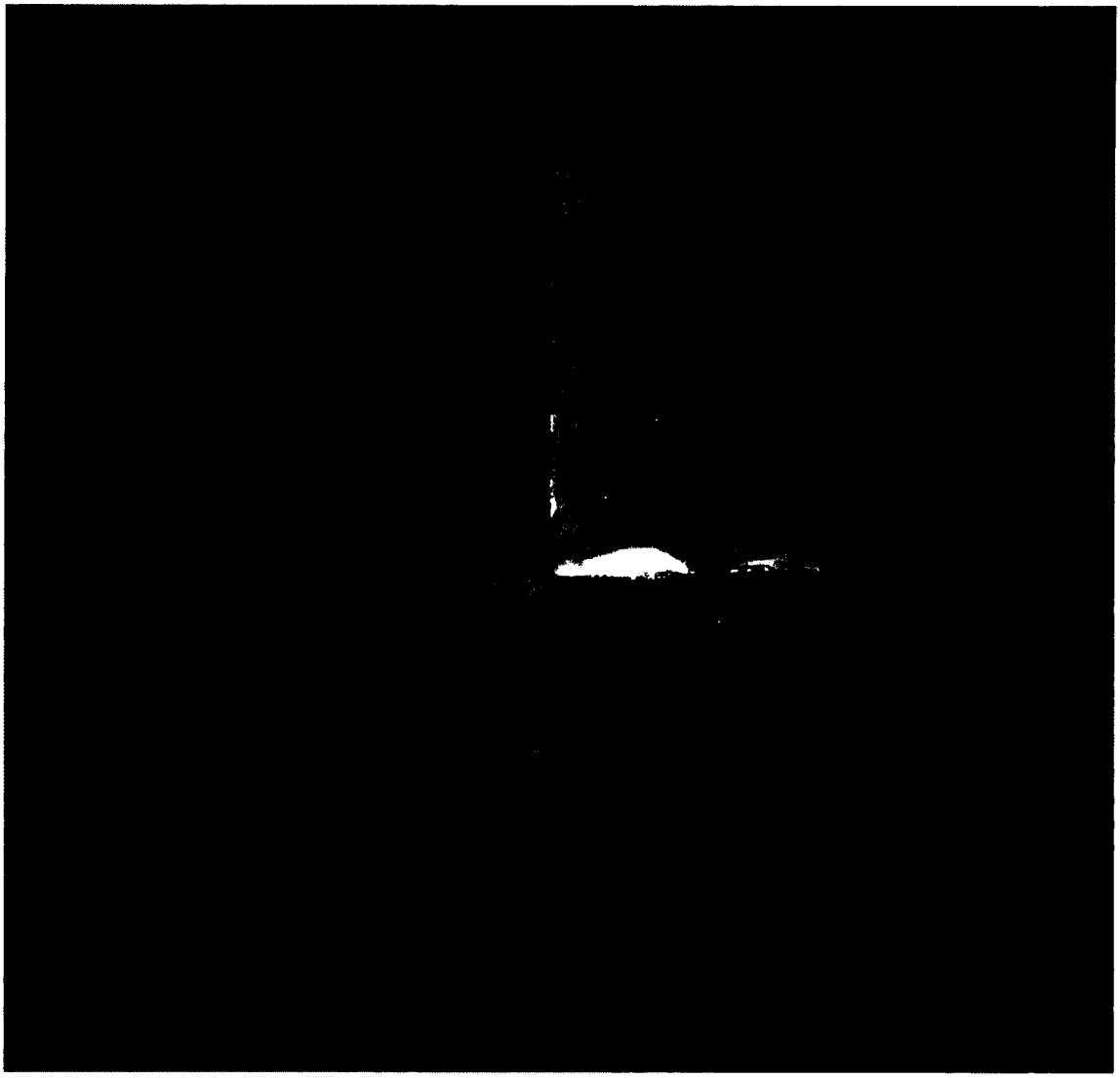

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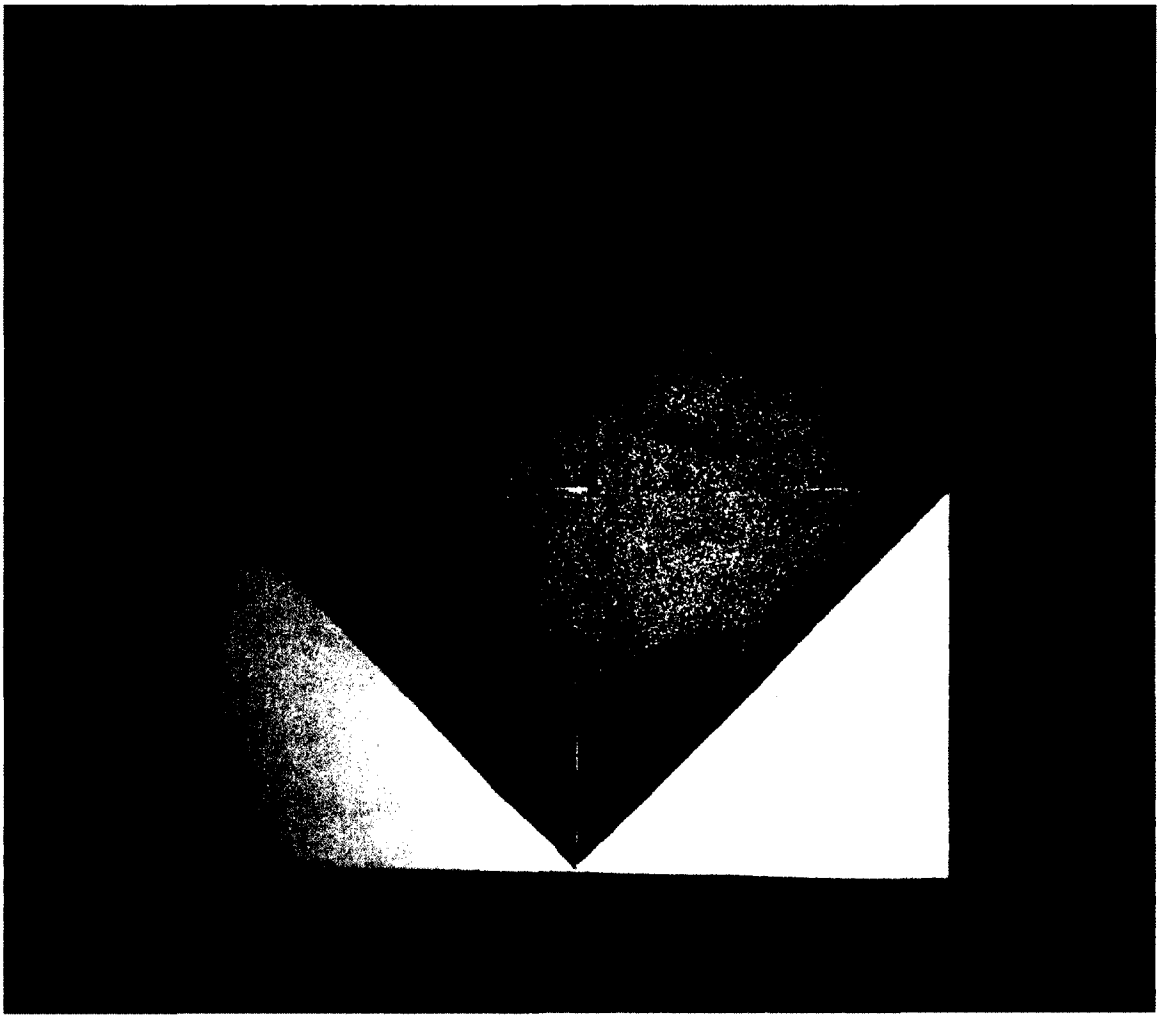

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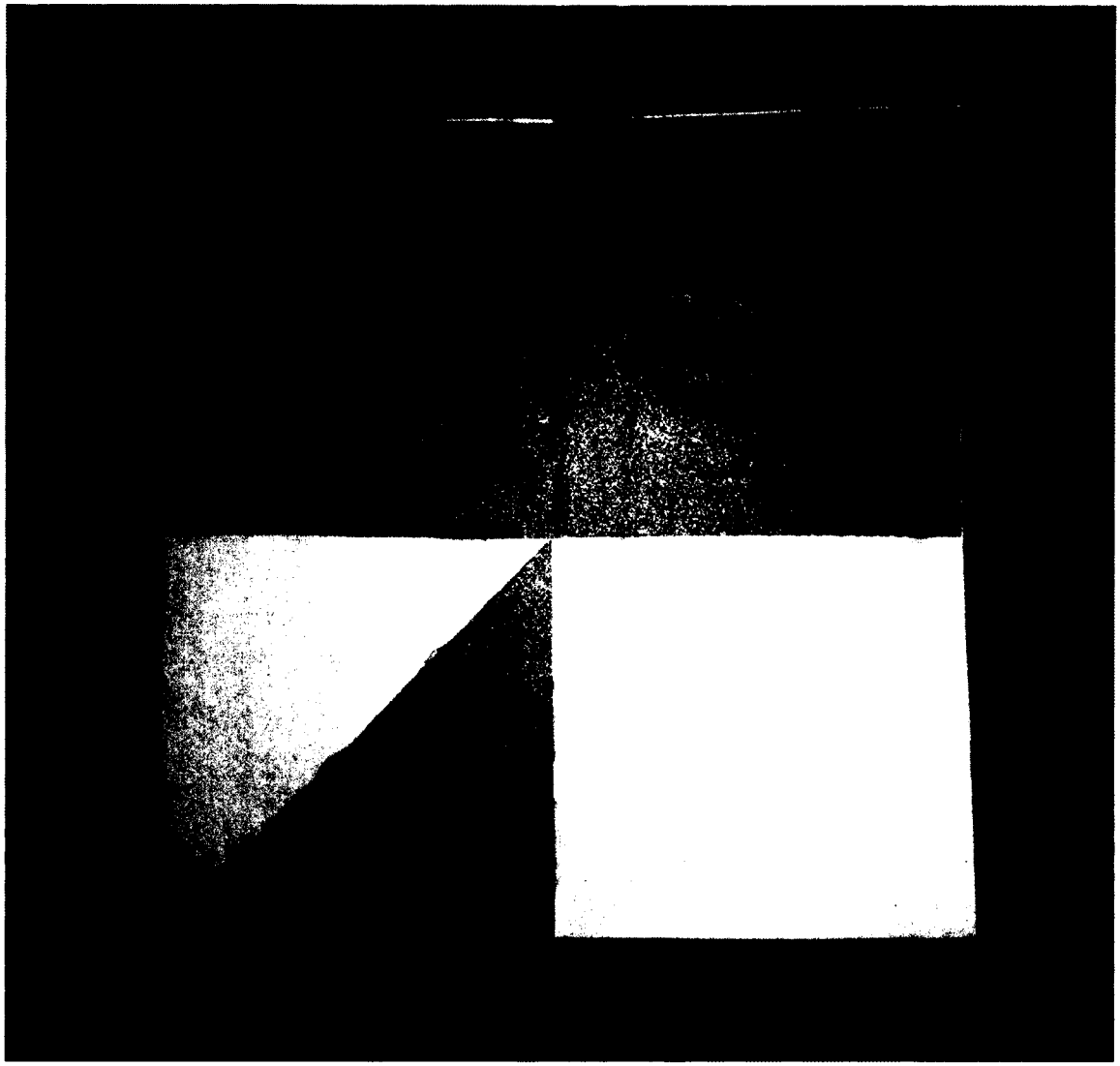

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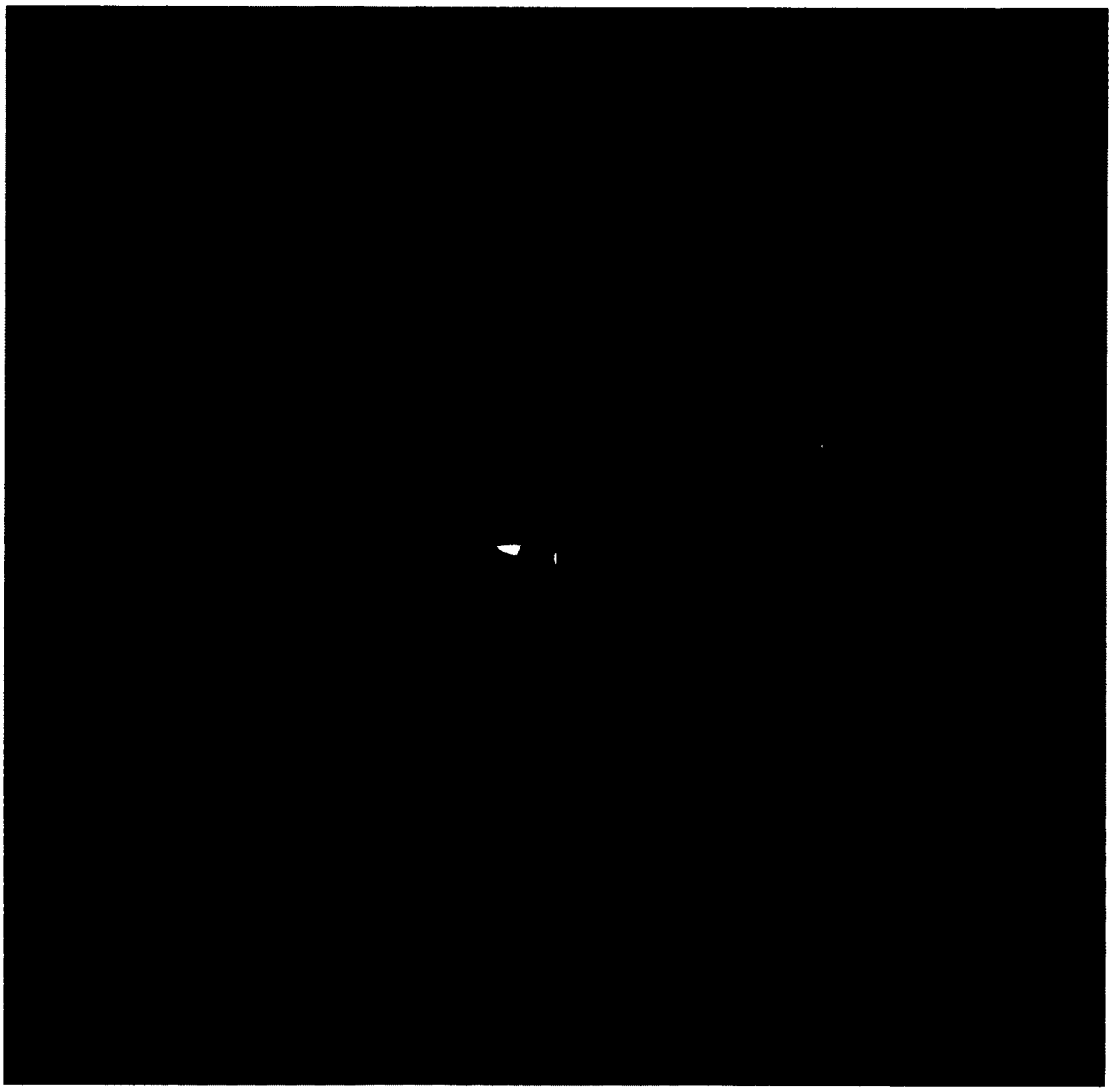

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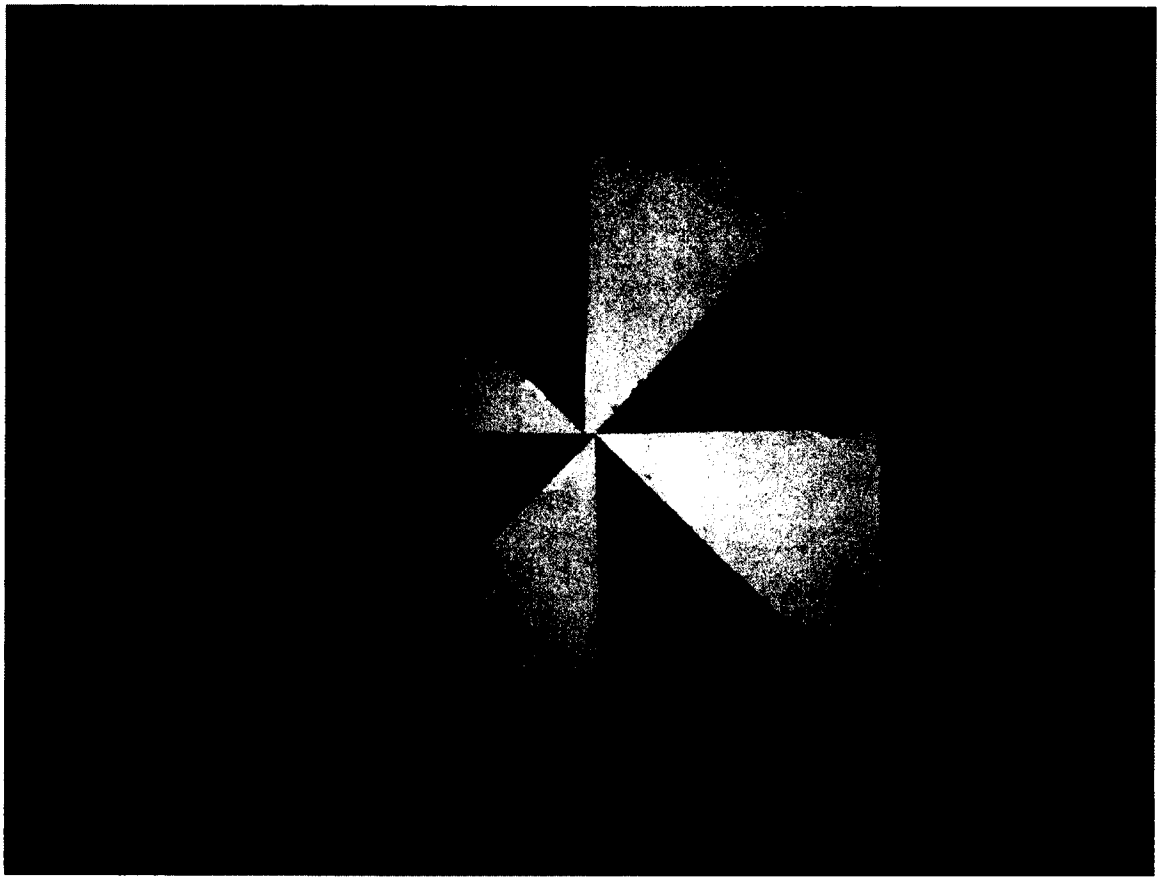

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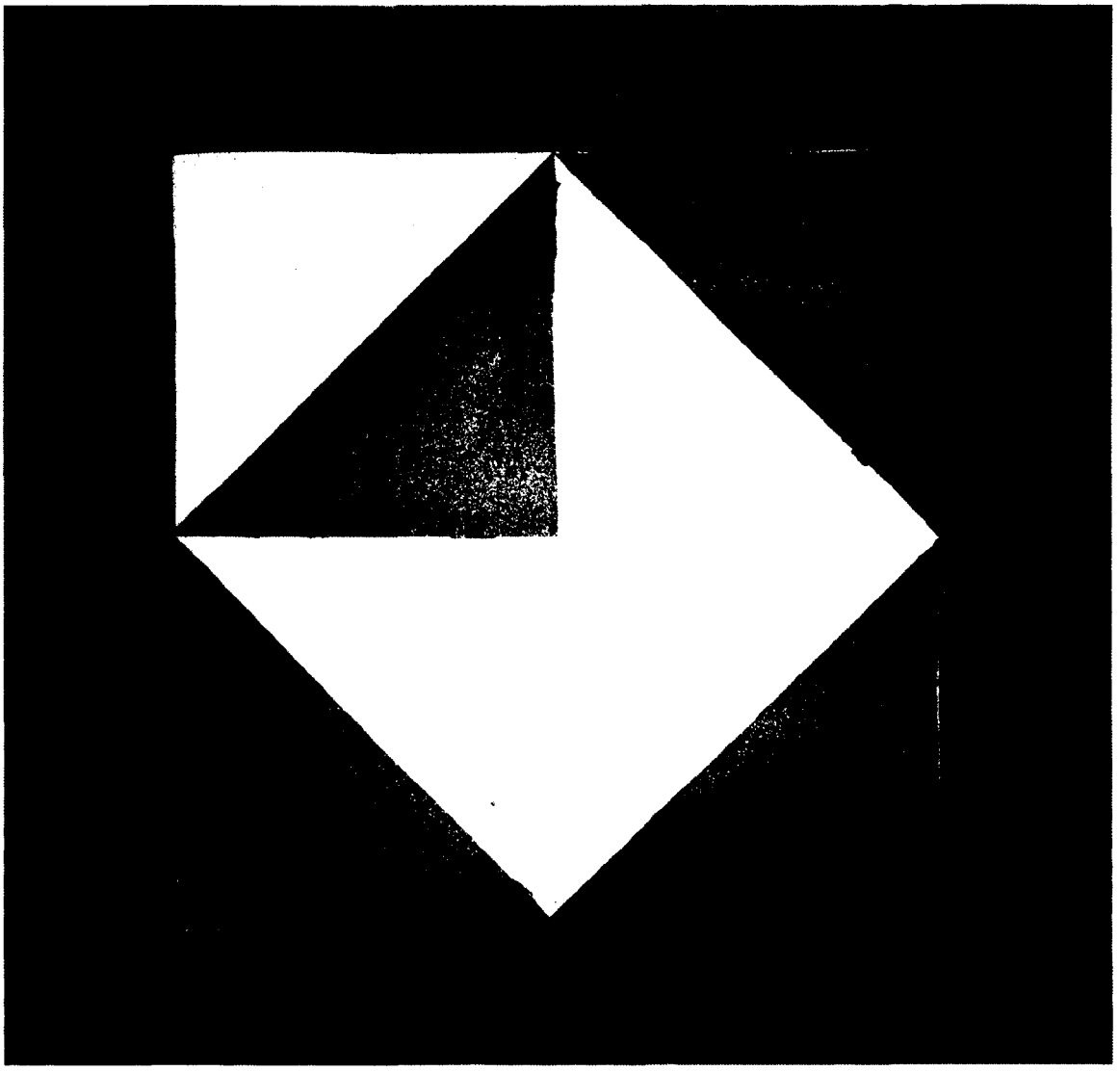

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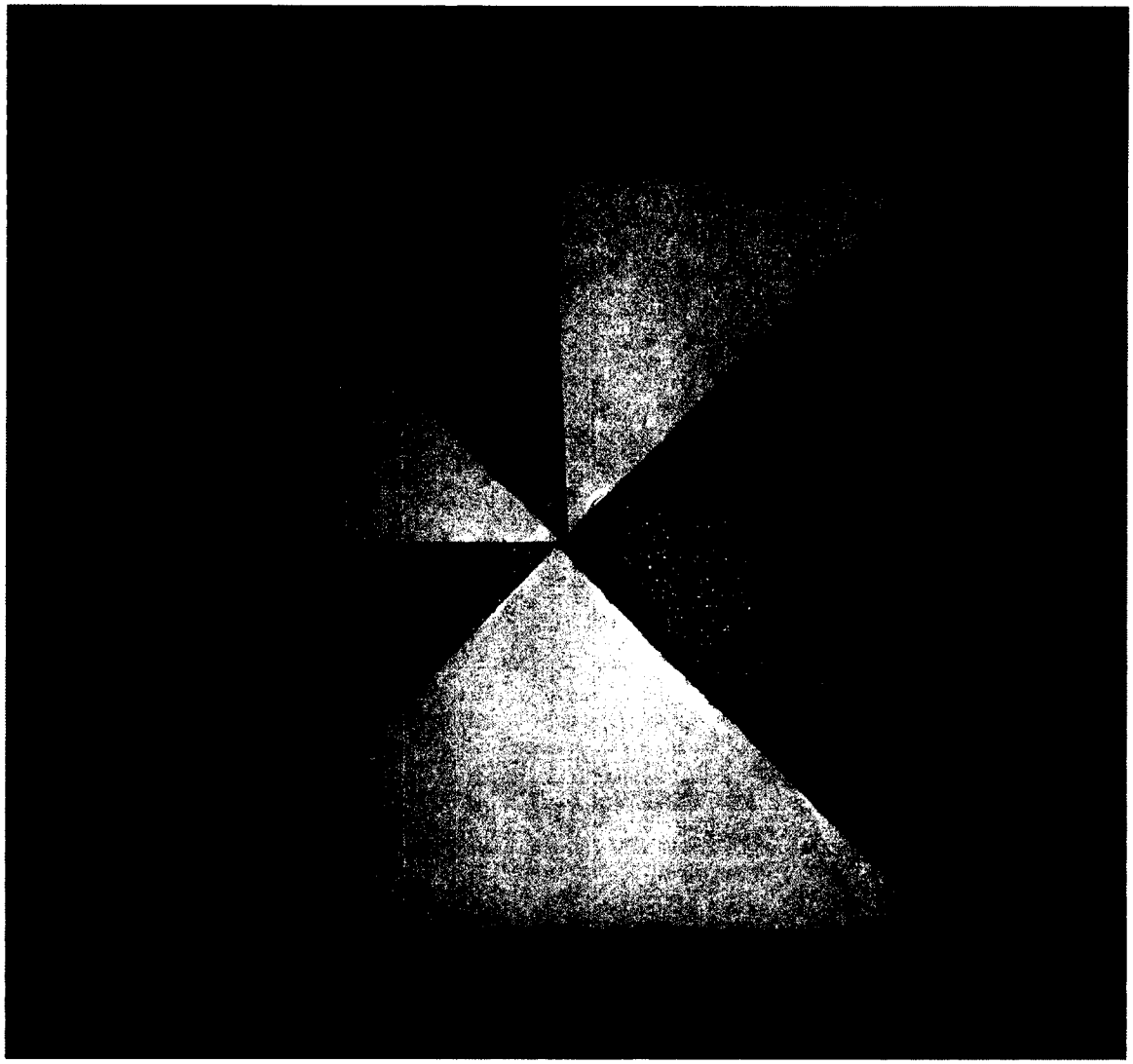

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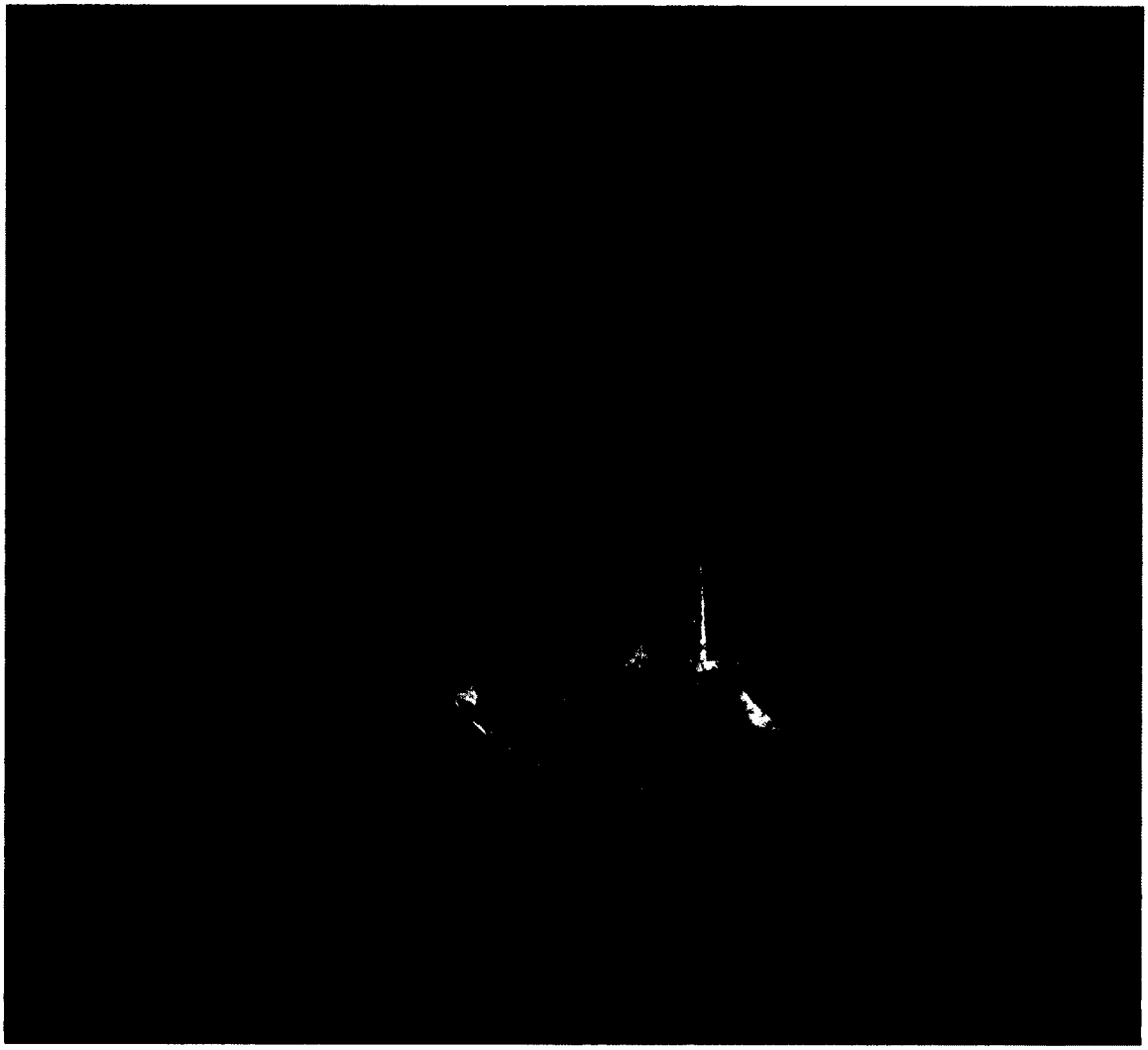

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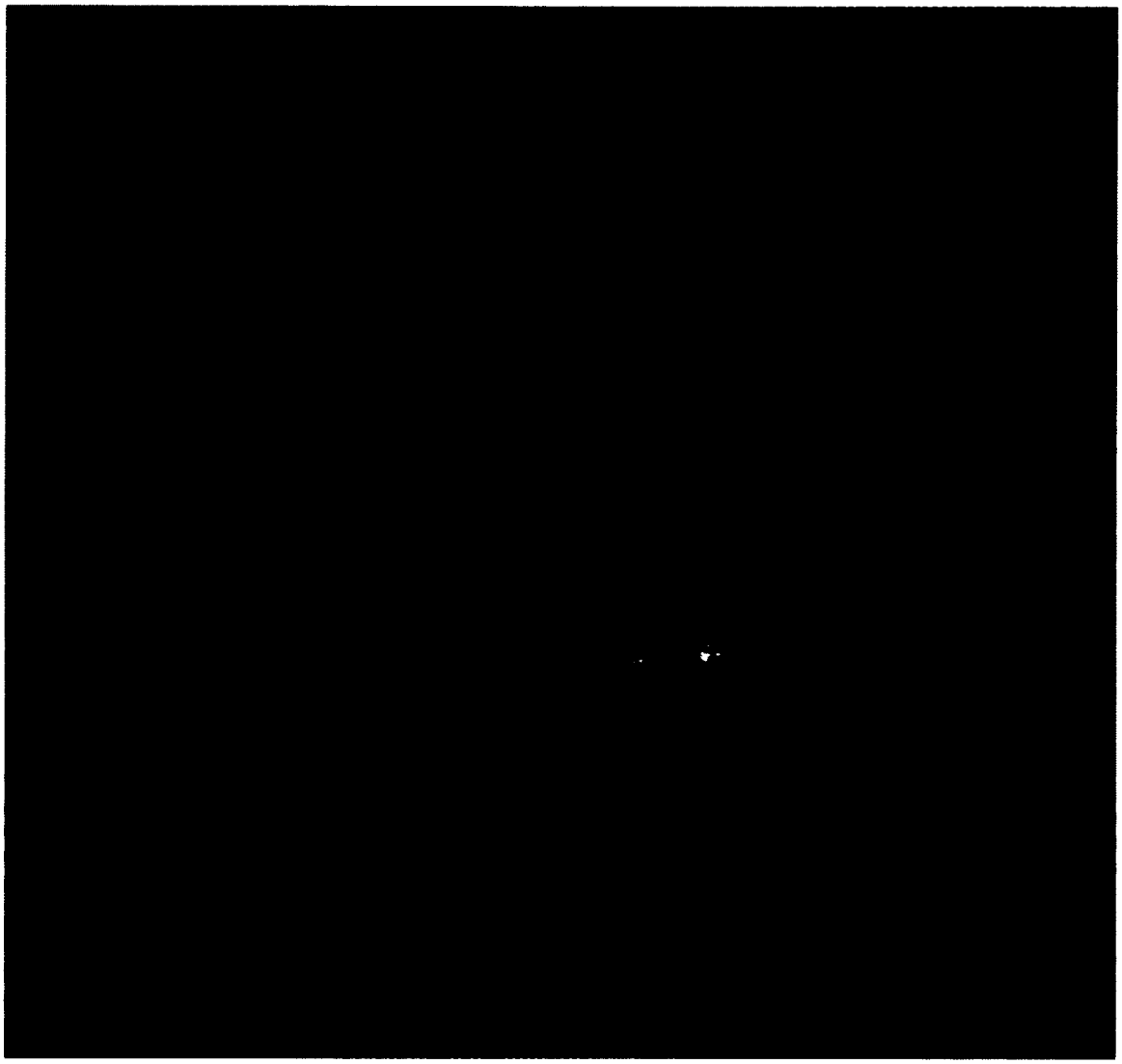

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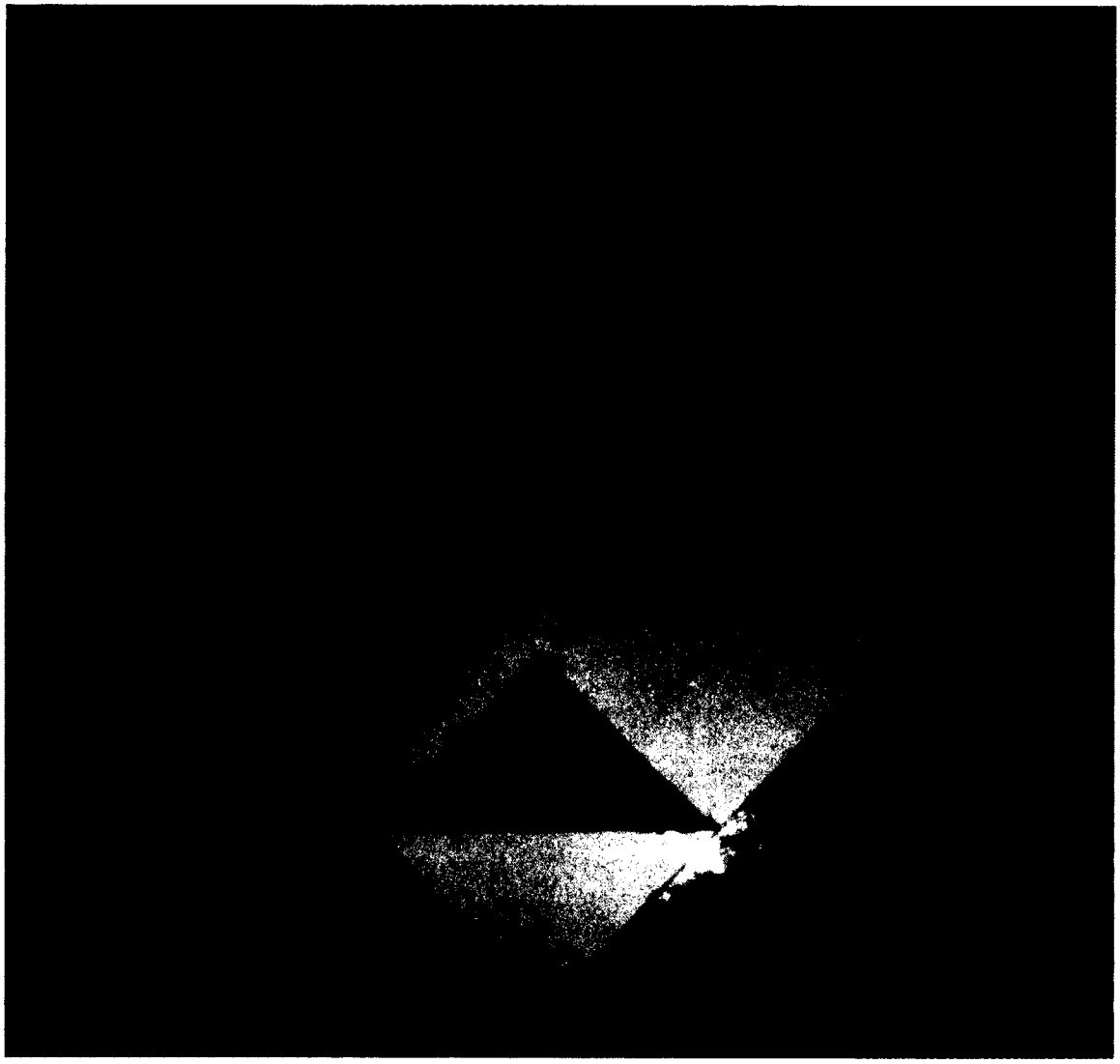

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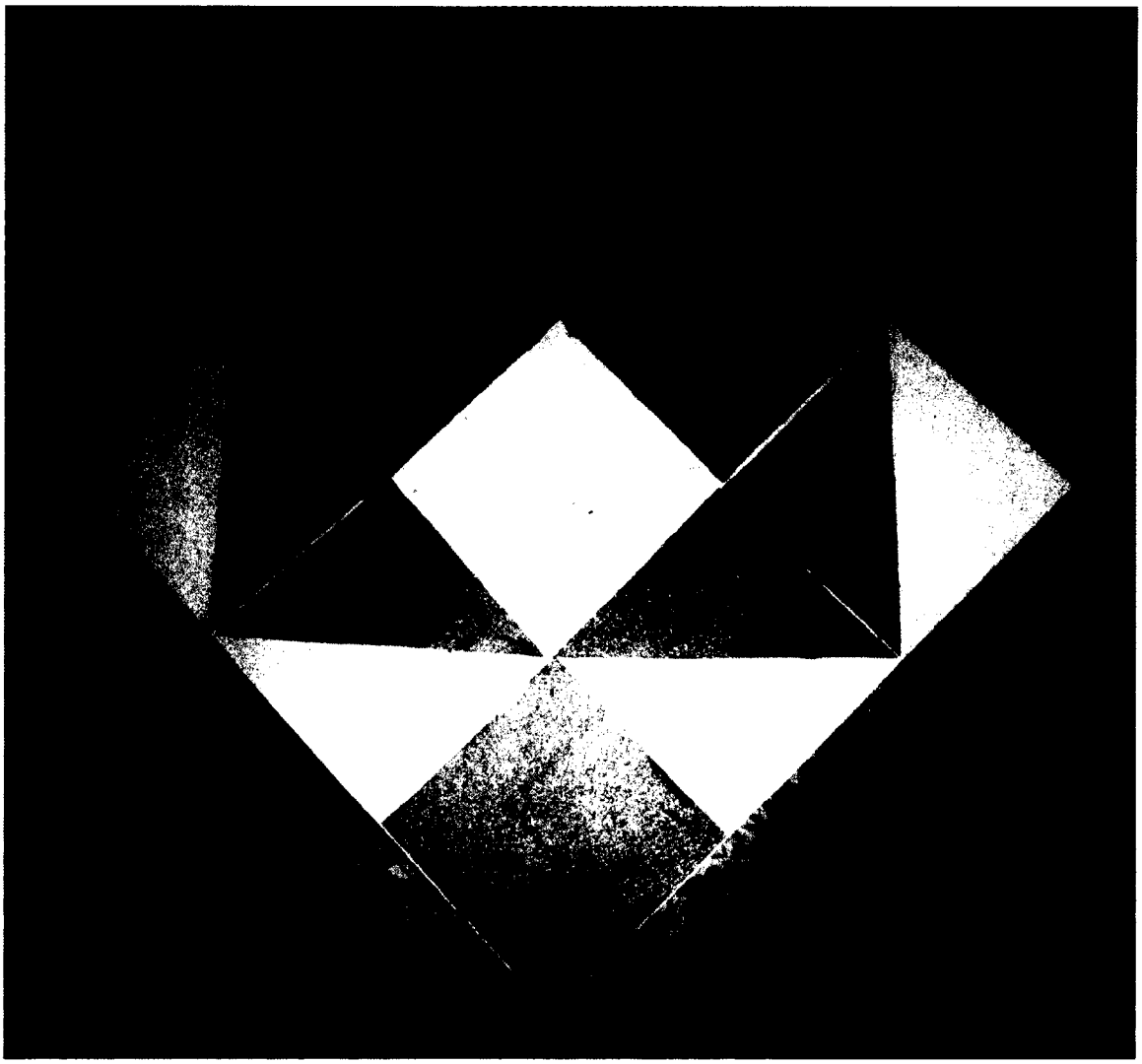
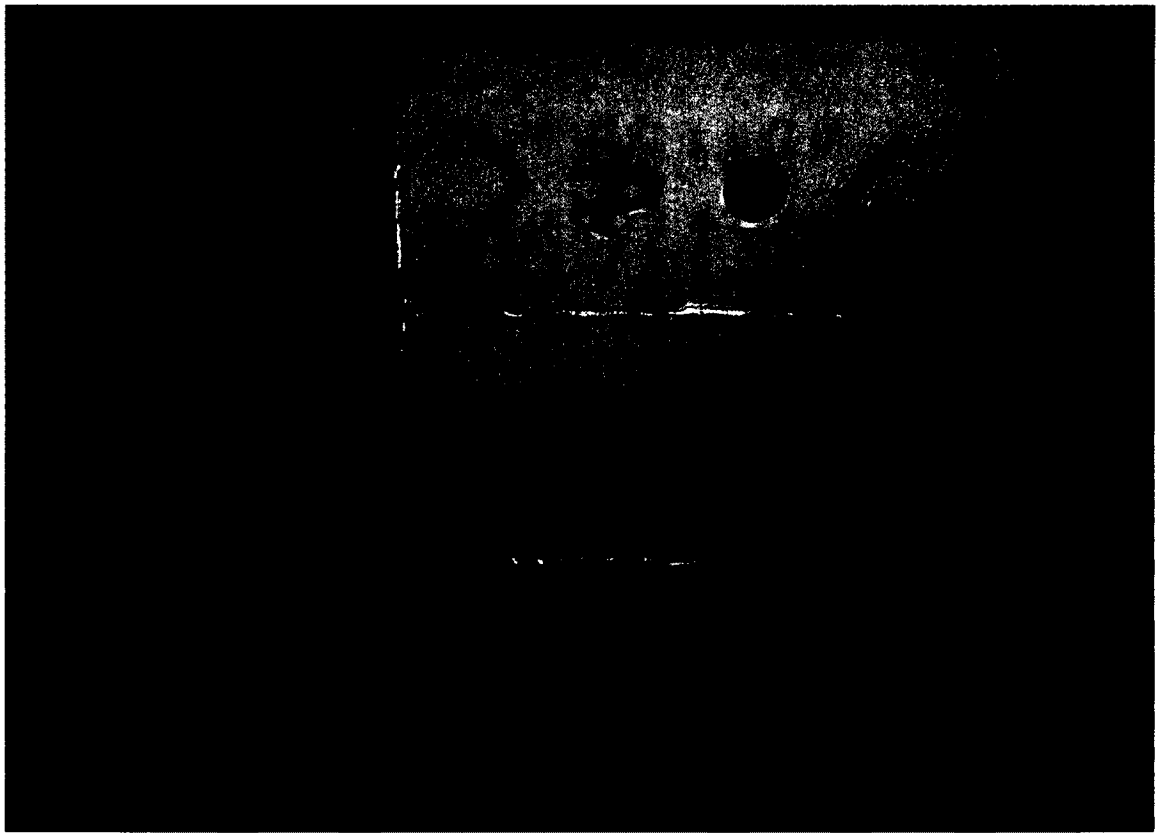


Tactile Tile Design

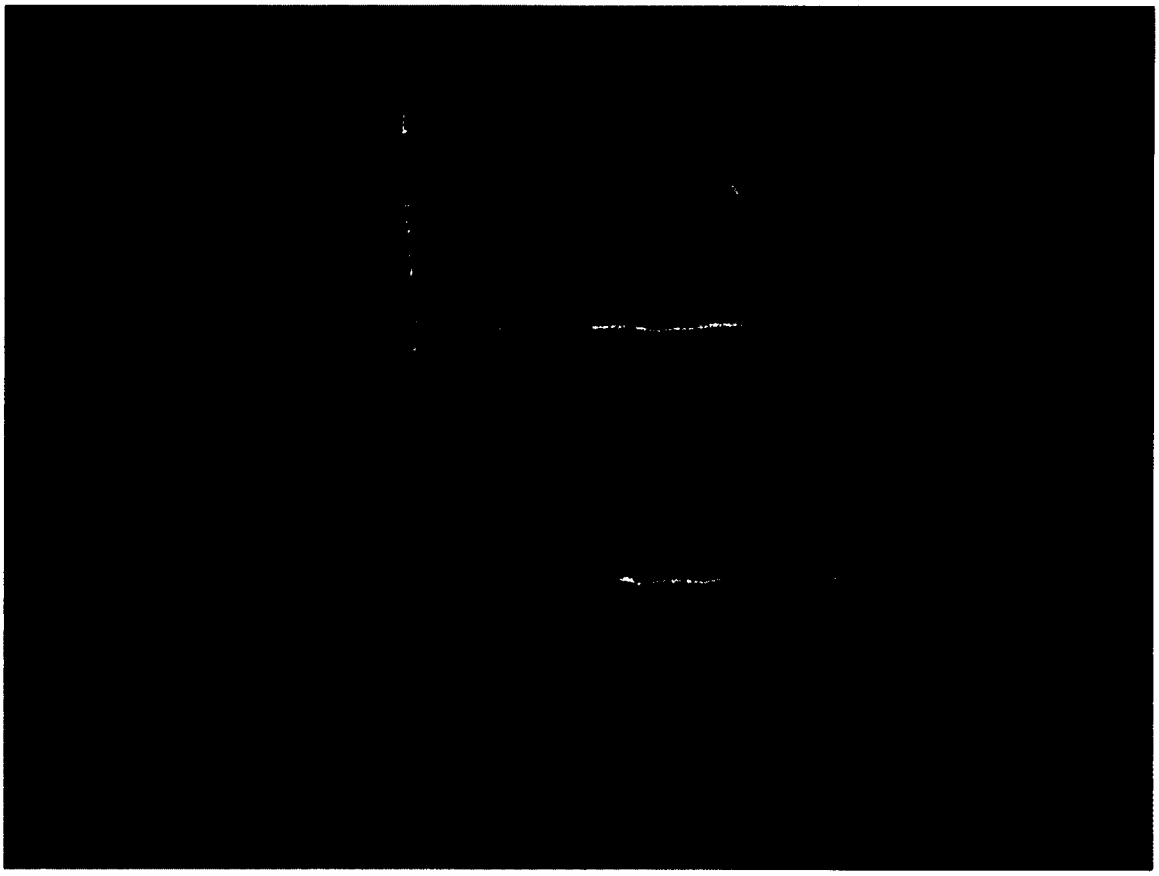
APPENDIX B

TACTILE FIGURE EXPLORATION

Tactile Figure Exploration



Tactile Figure Exploration



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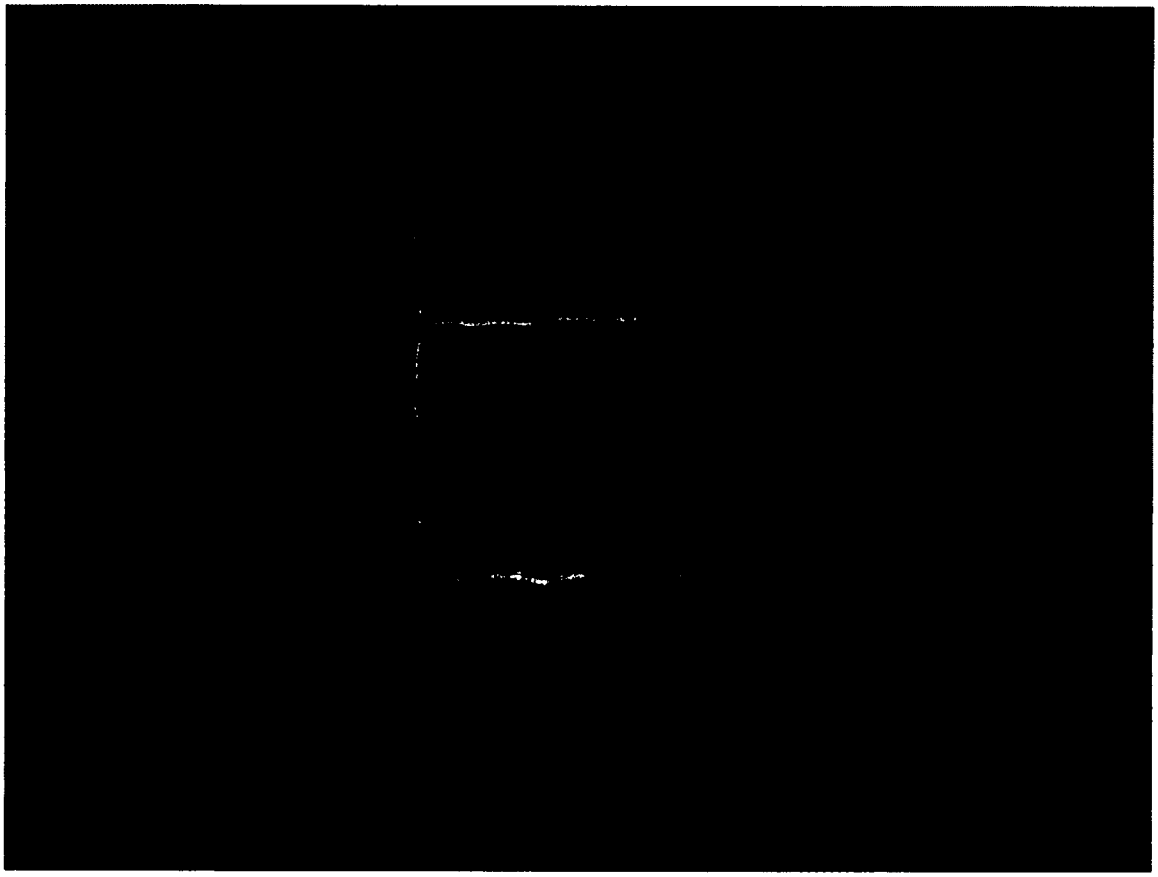
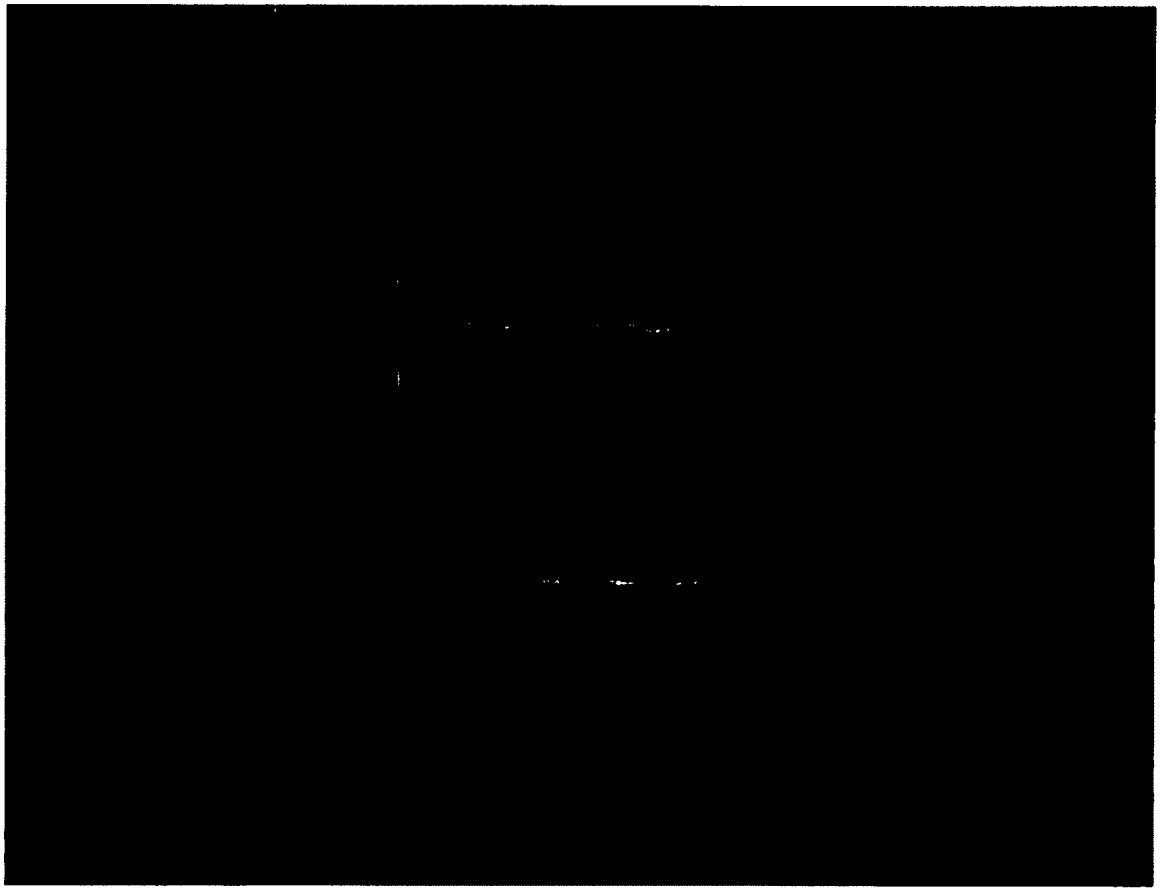


Tactile Figure Exploration

Tactile Figure Exploration



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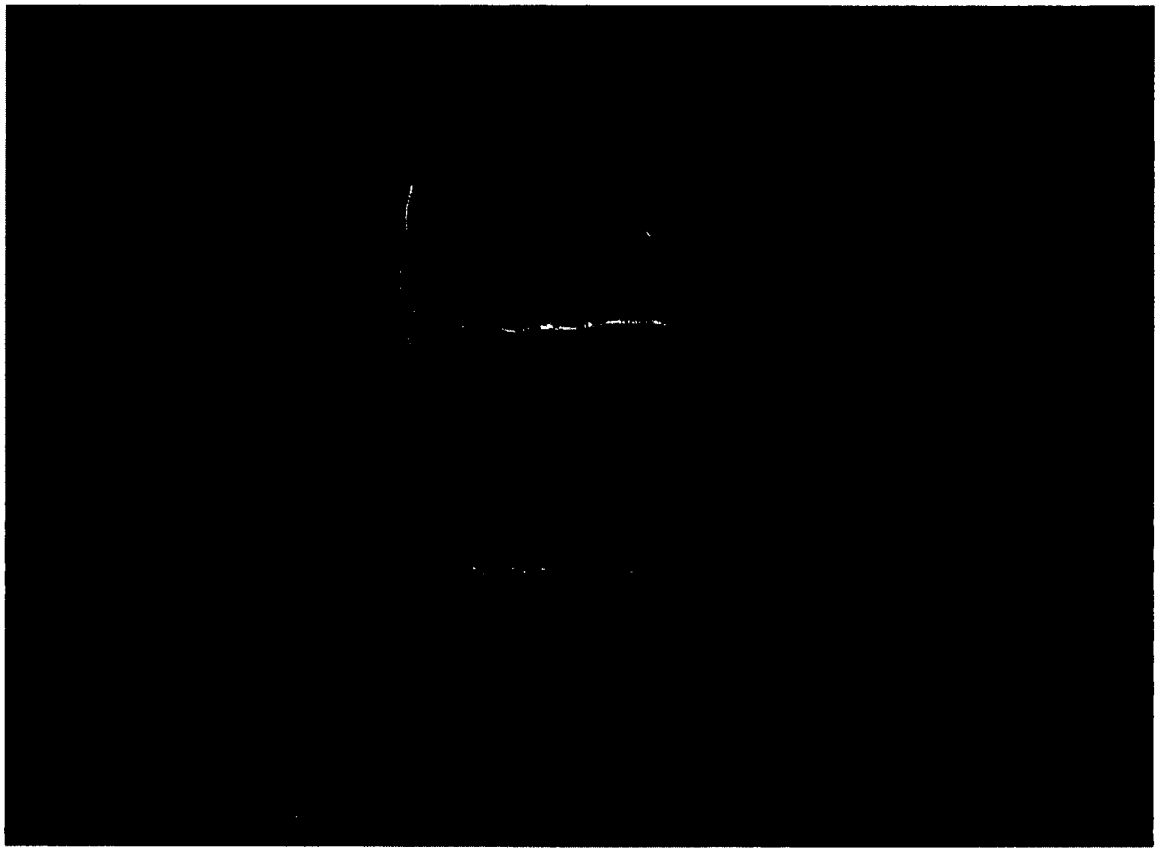
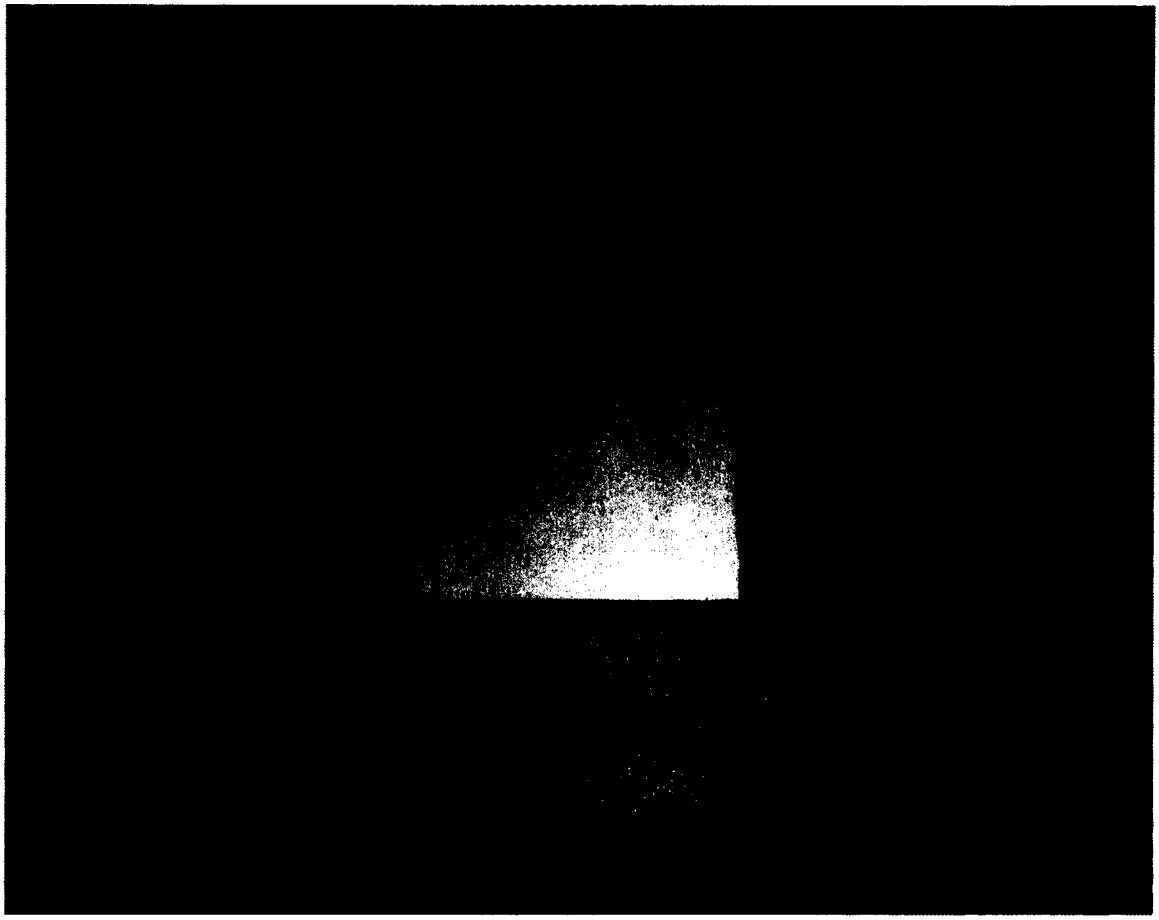


Tactile Figure Exploration

Tactile Figure Exploration

APPENDIX C

TACTILE FIGURE-GROUND IDENTIFICATION



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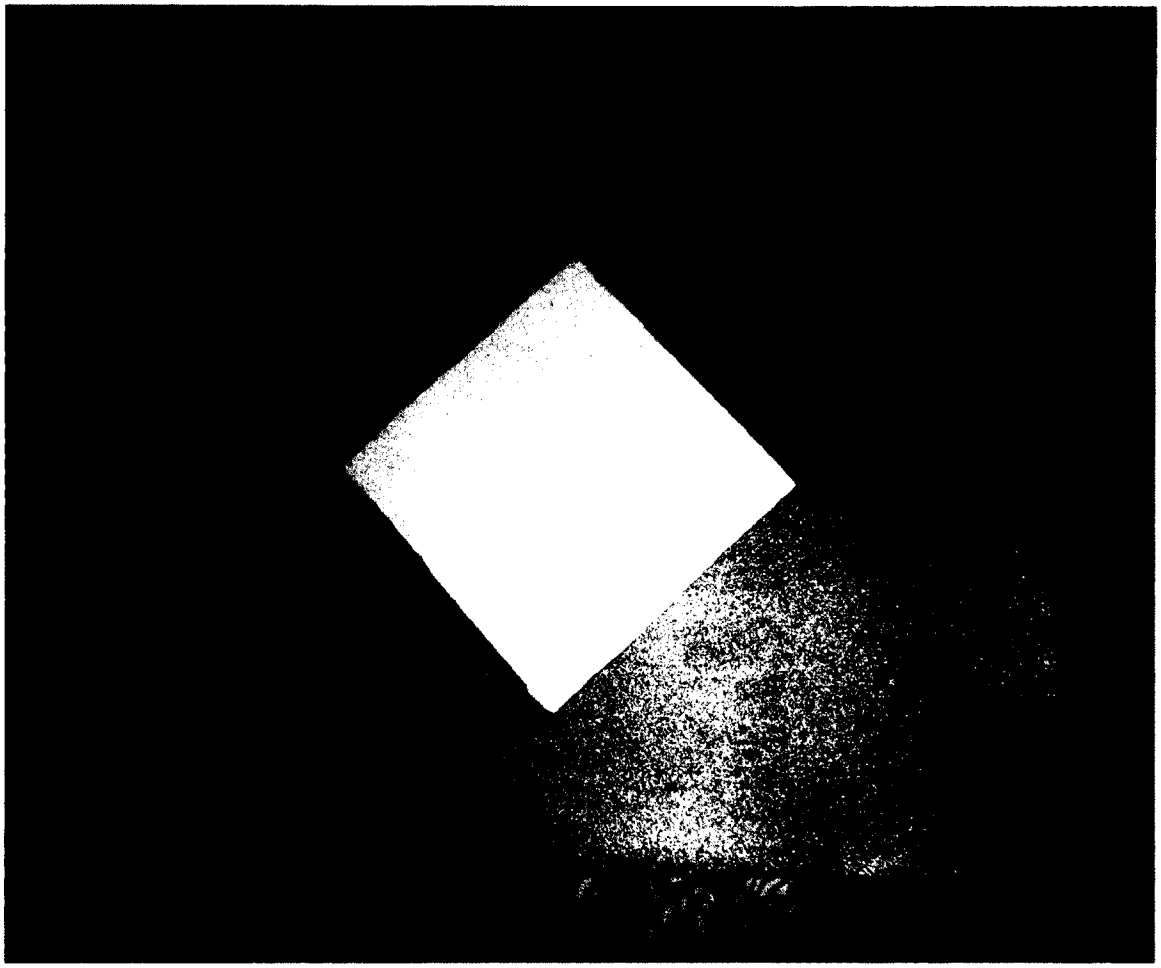

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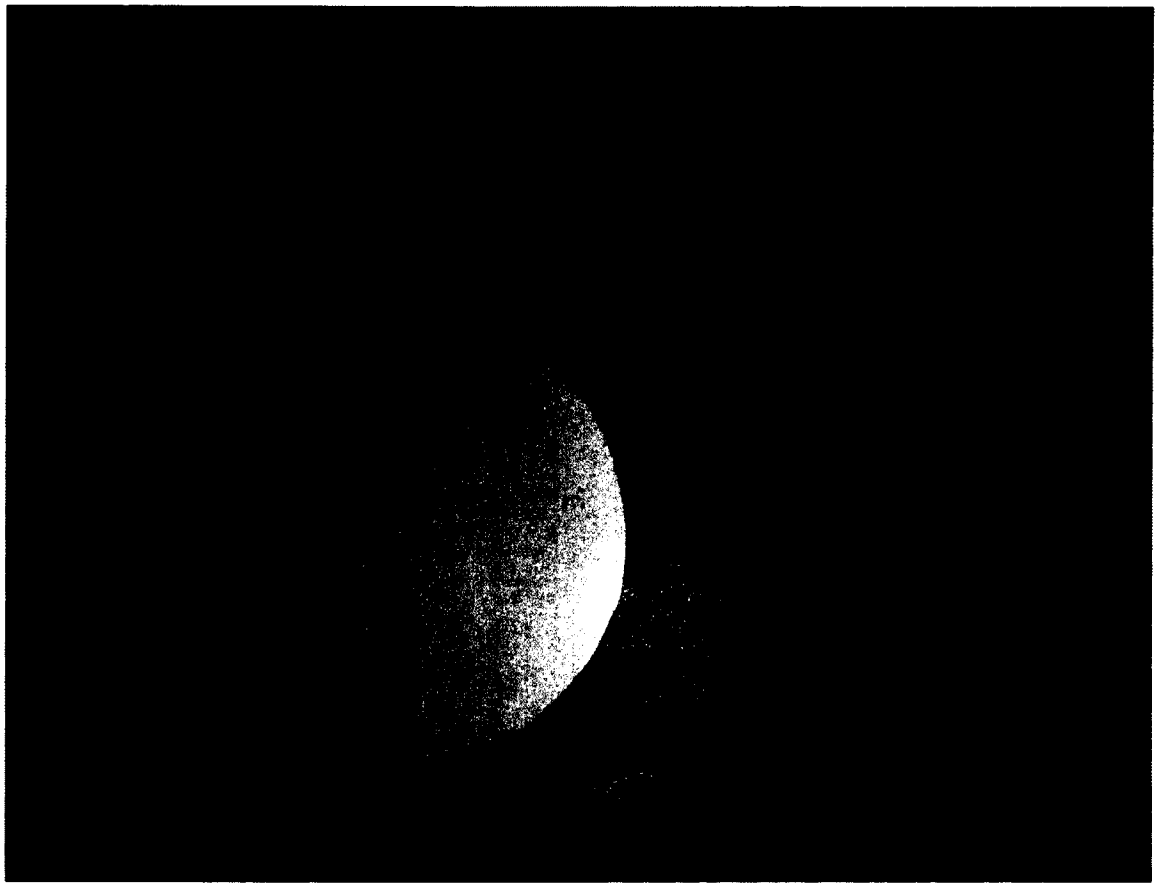

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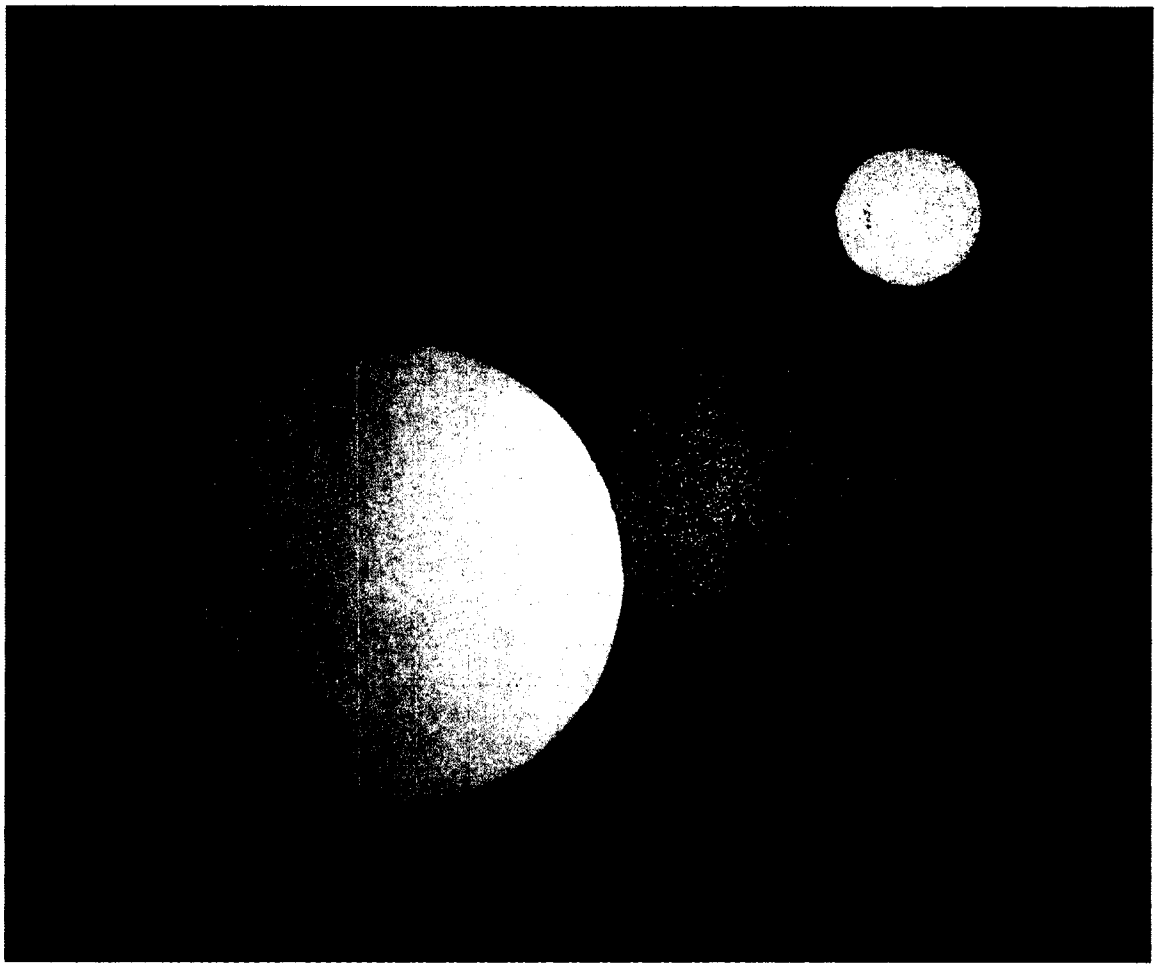

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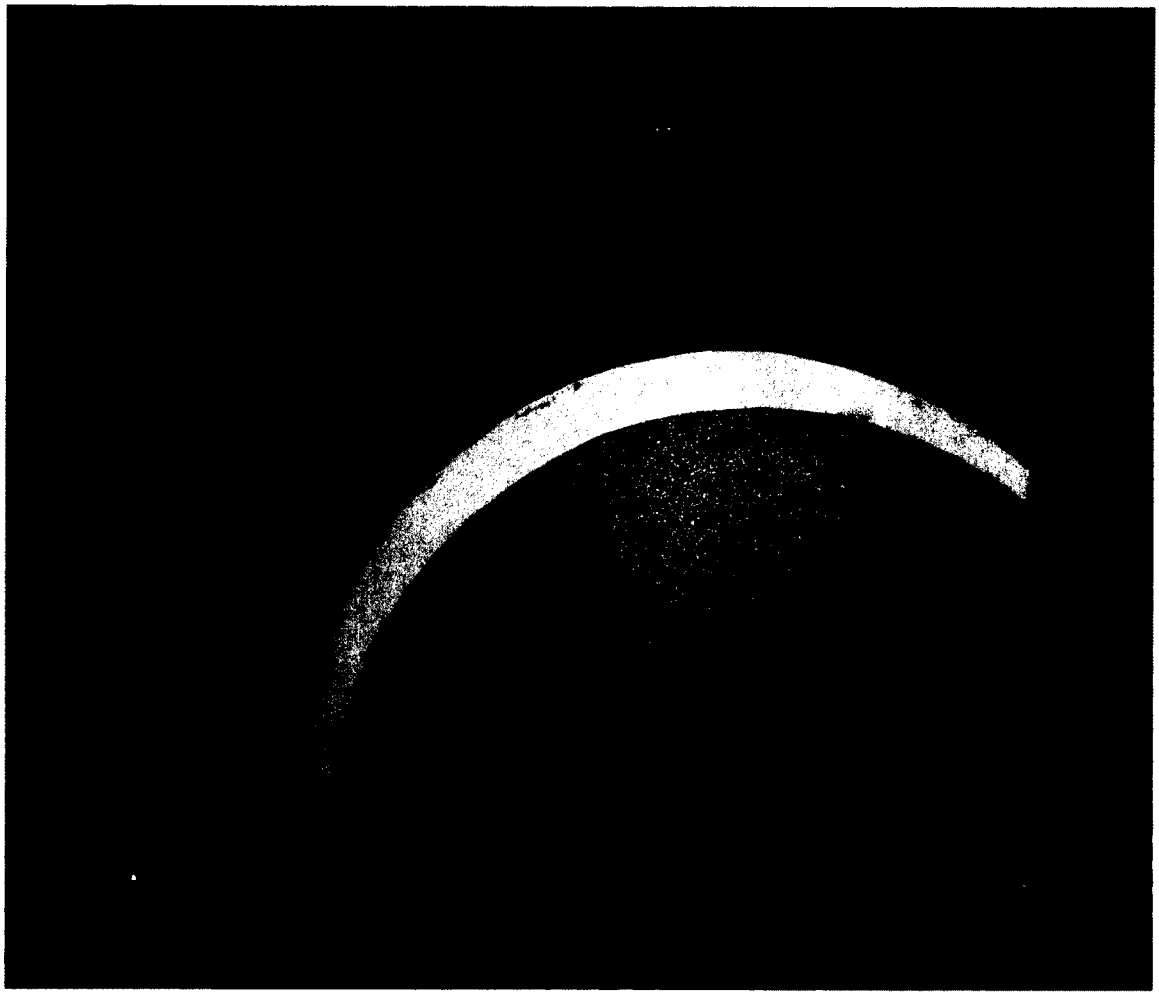

Tactile Figure-Ground Identification

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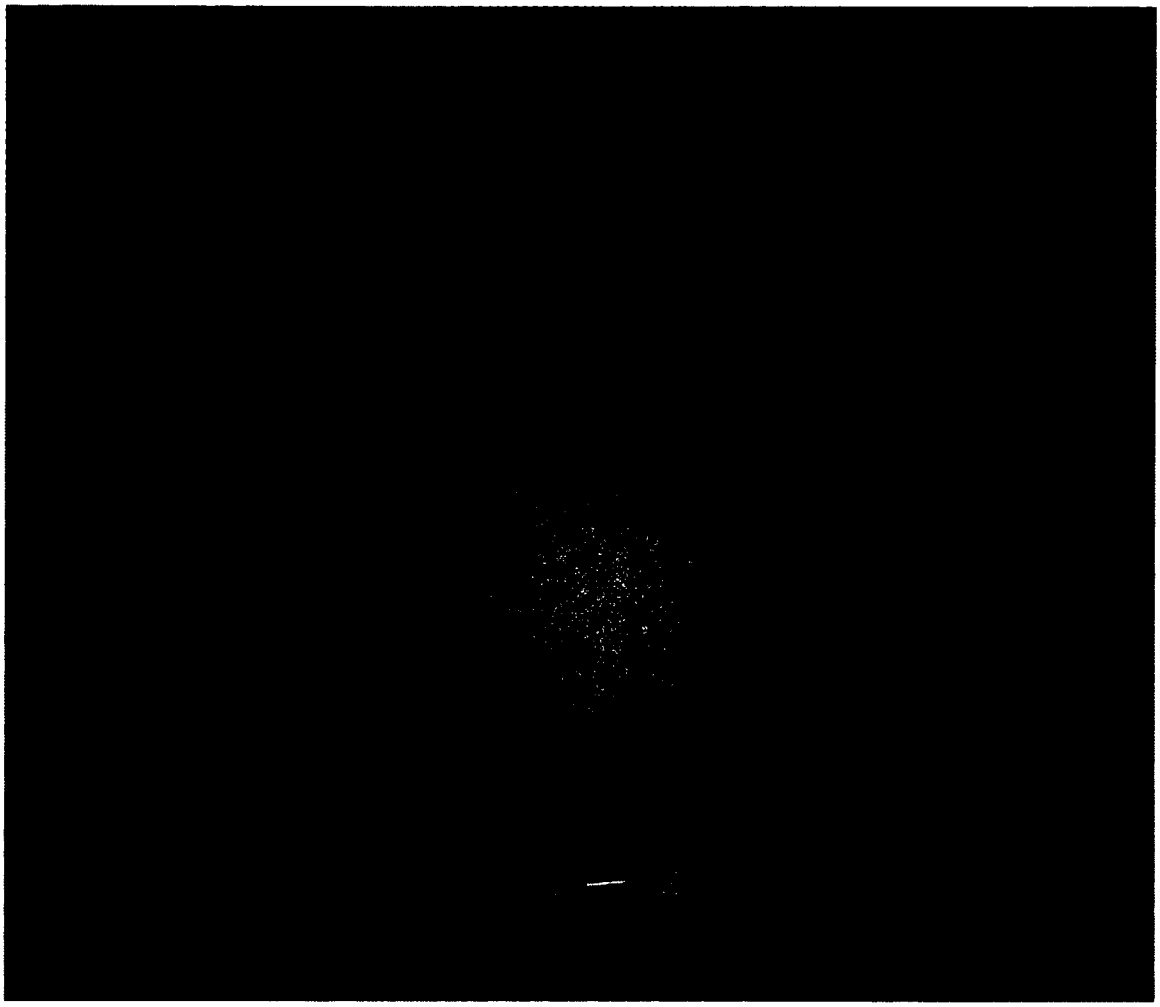

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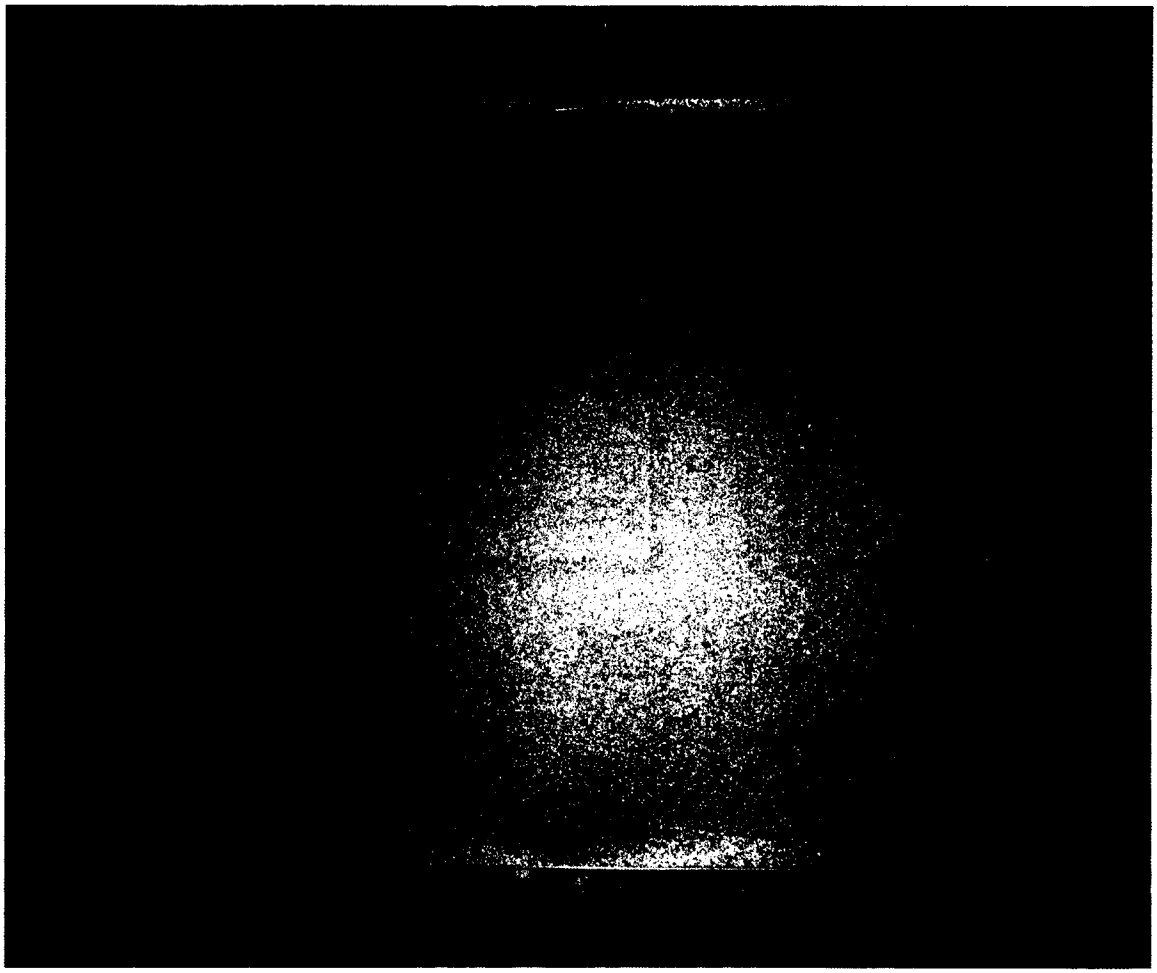

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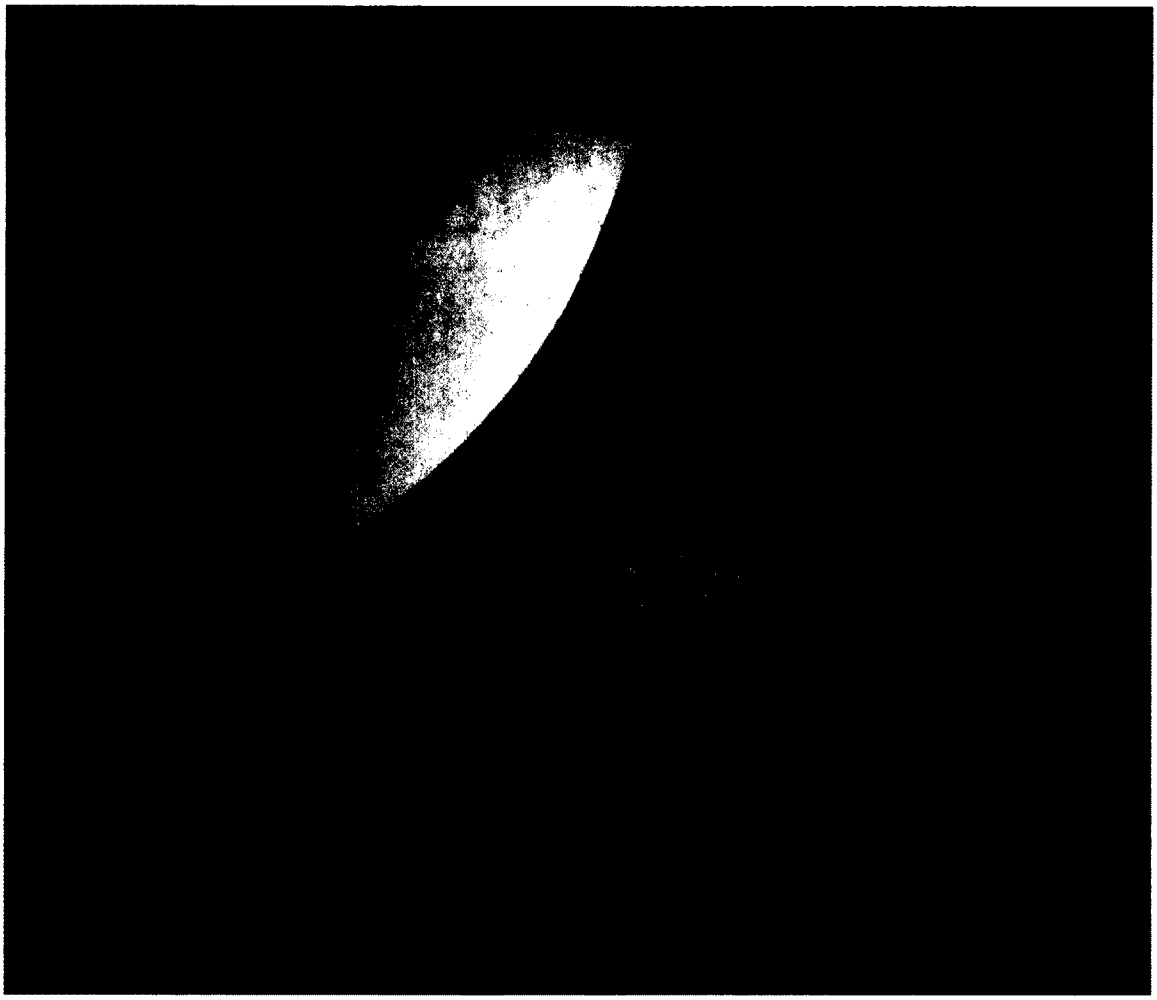

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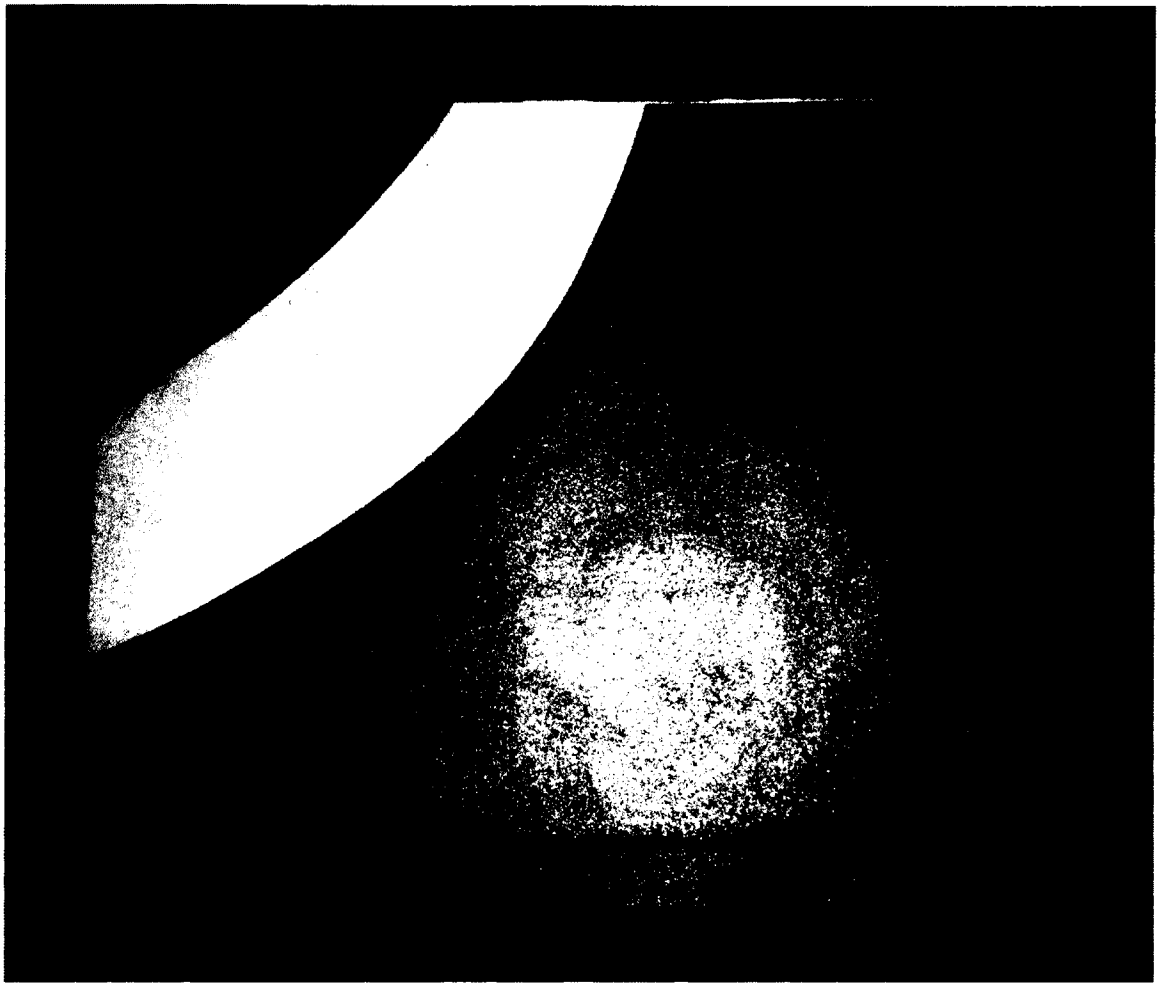

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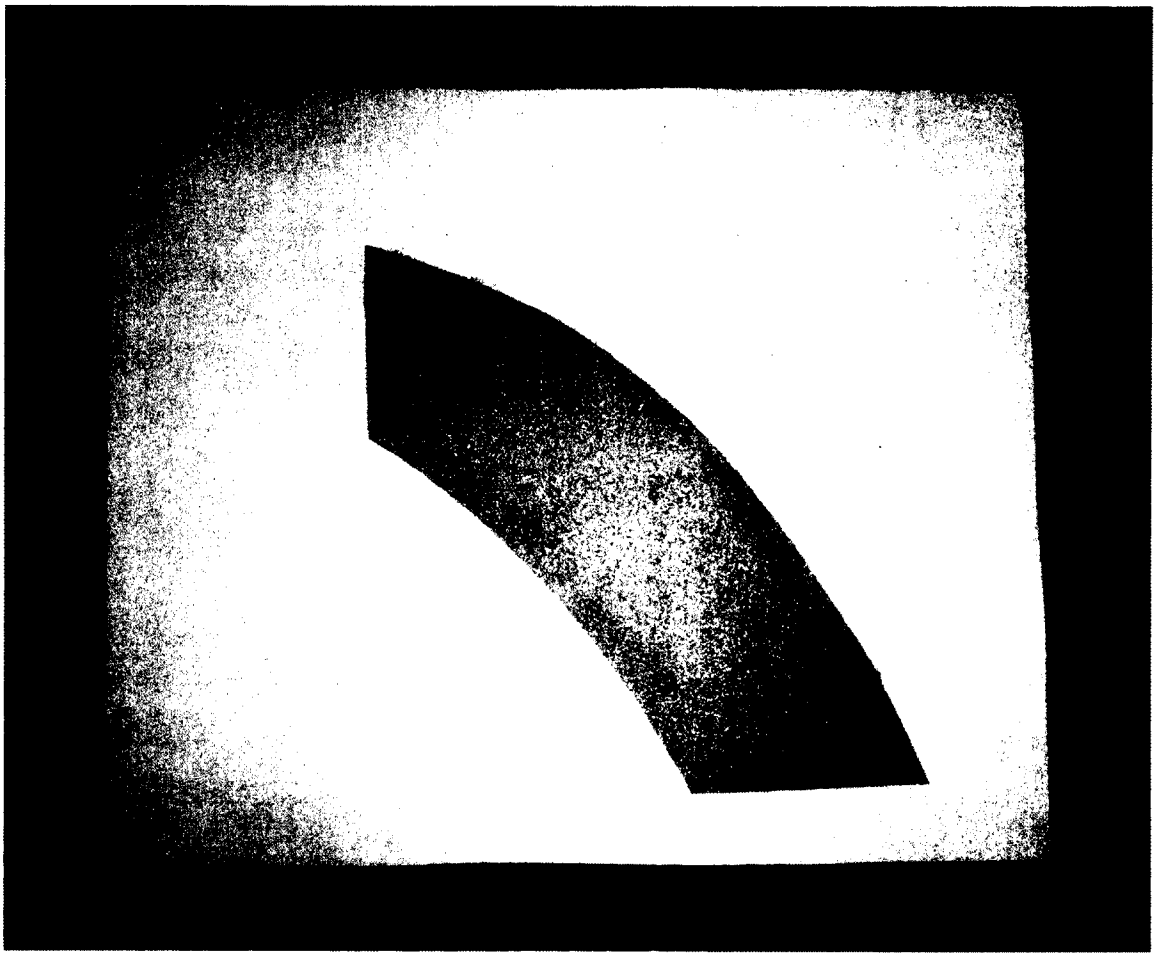

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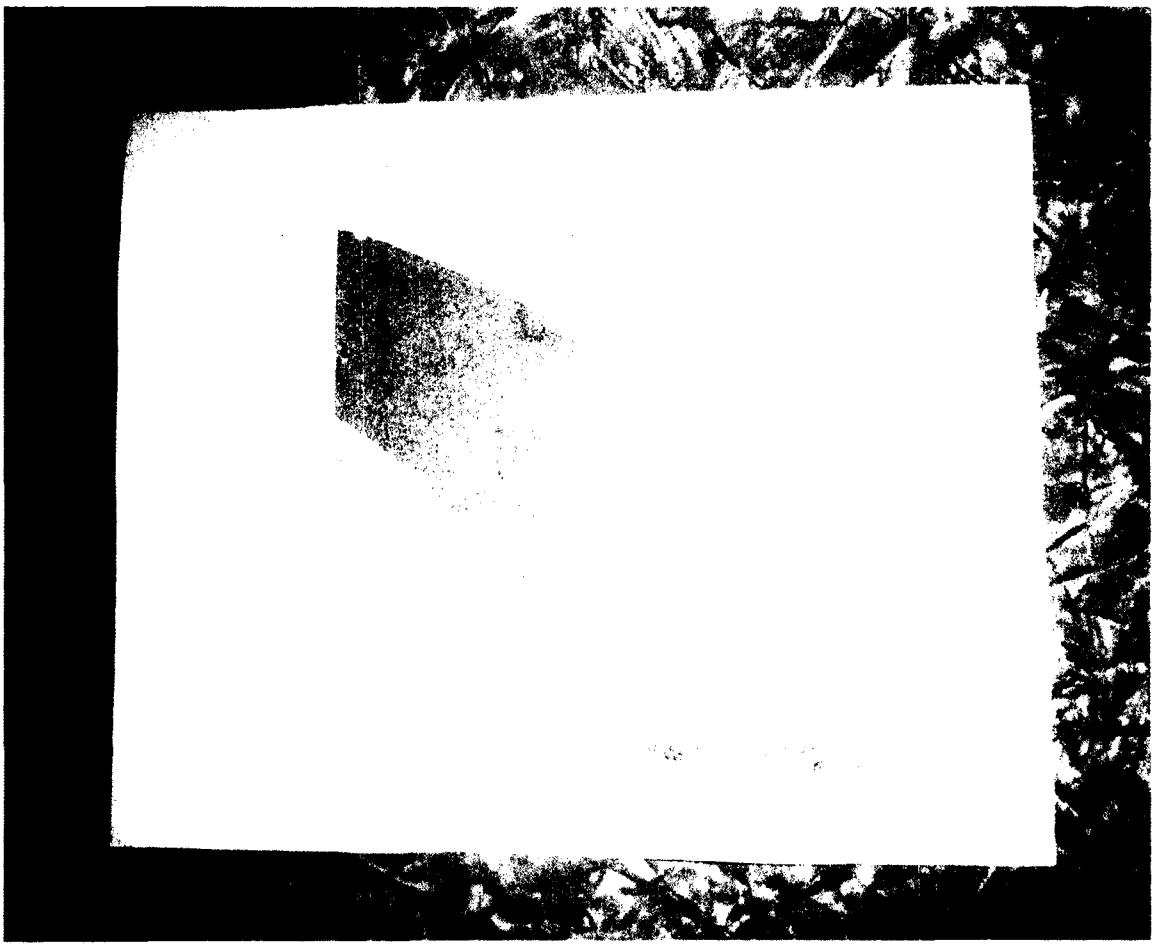

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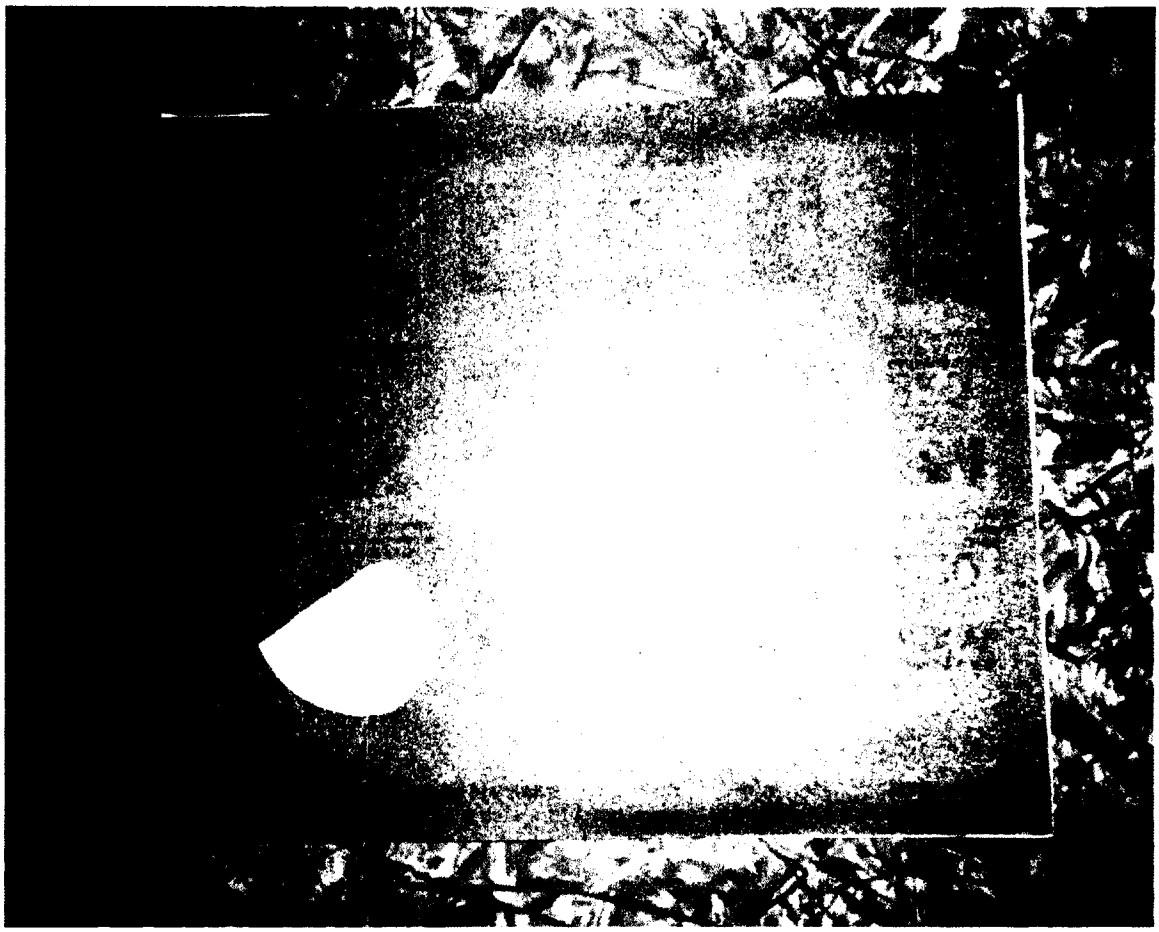

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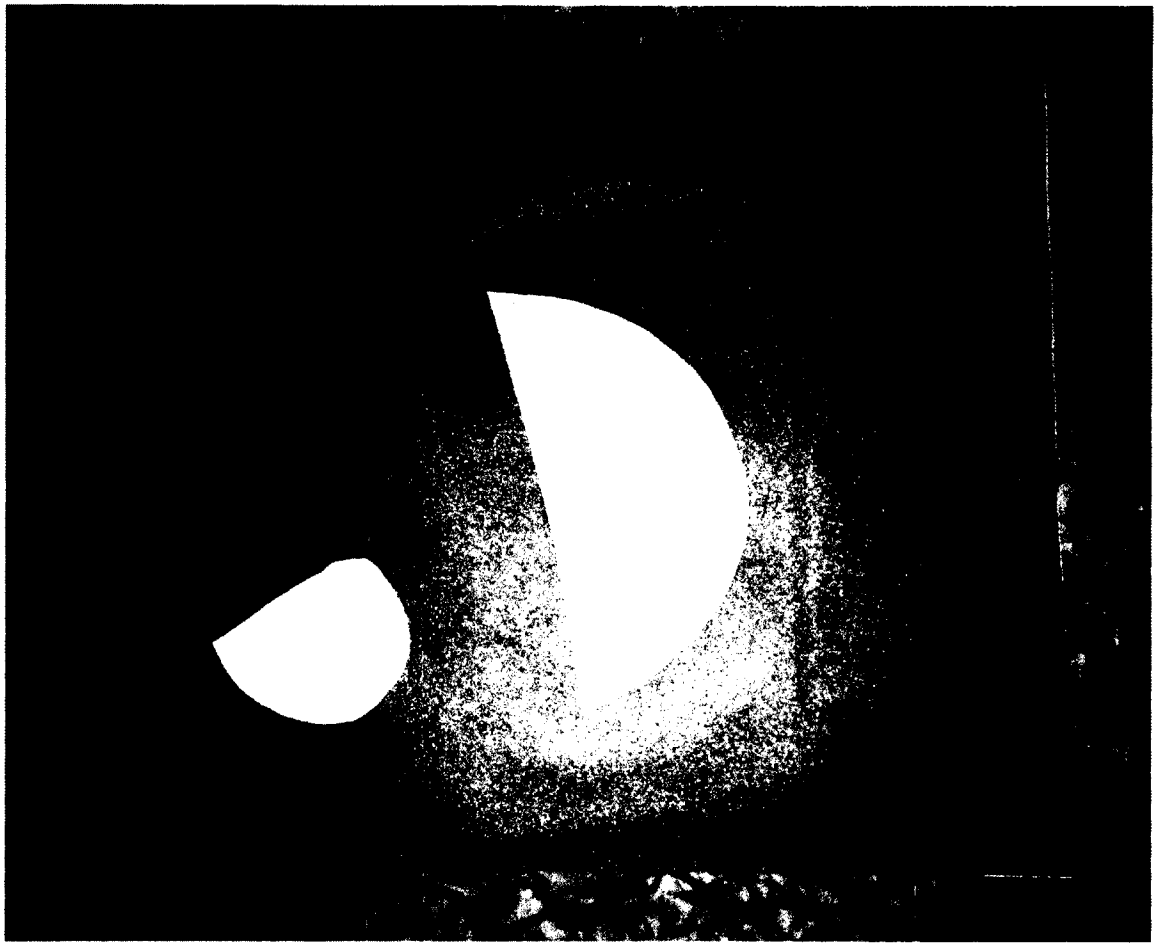

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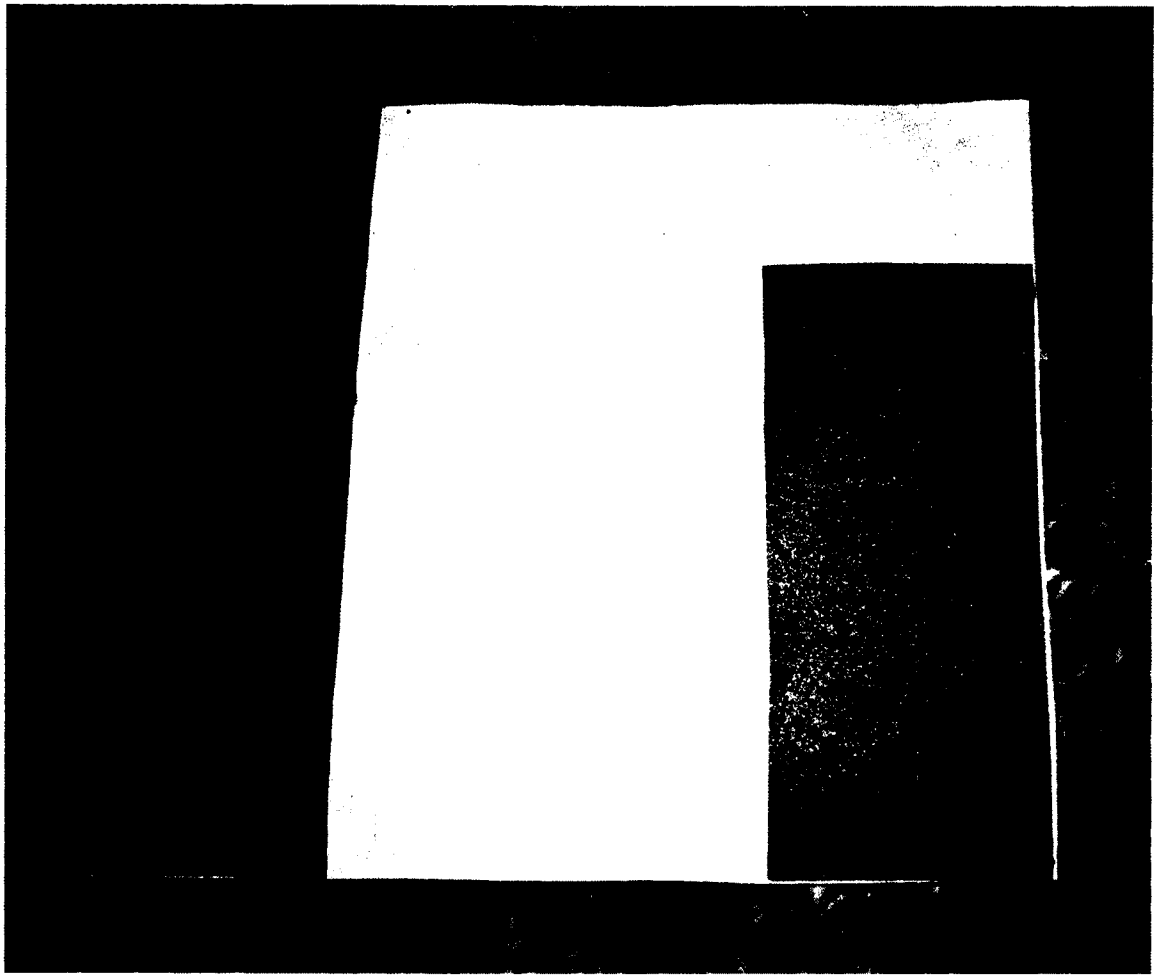

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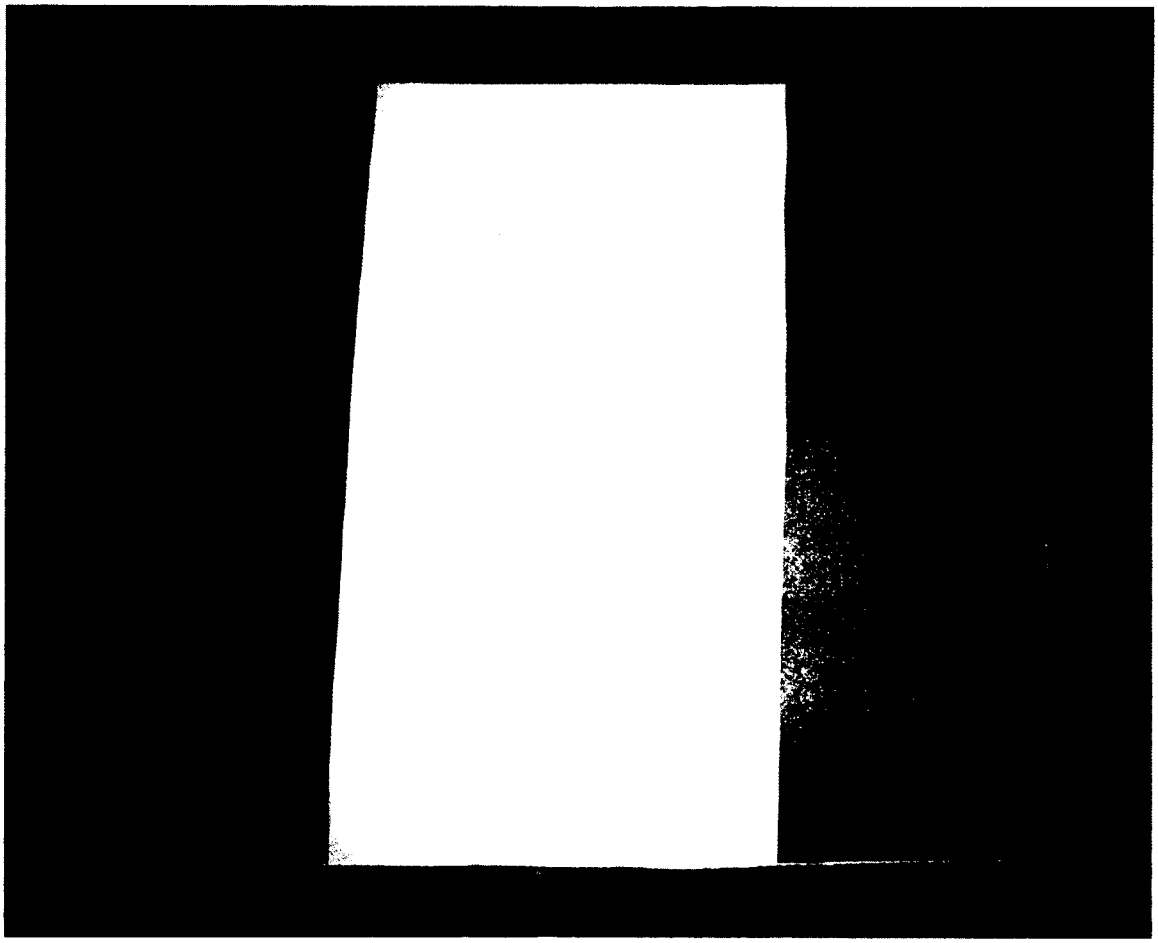

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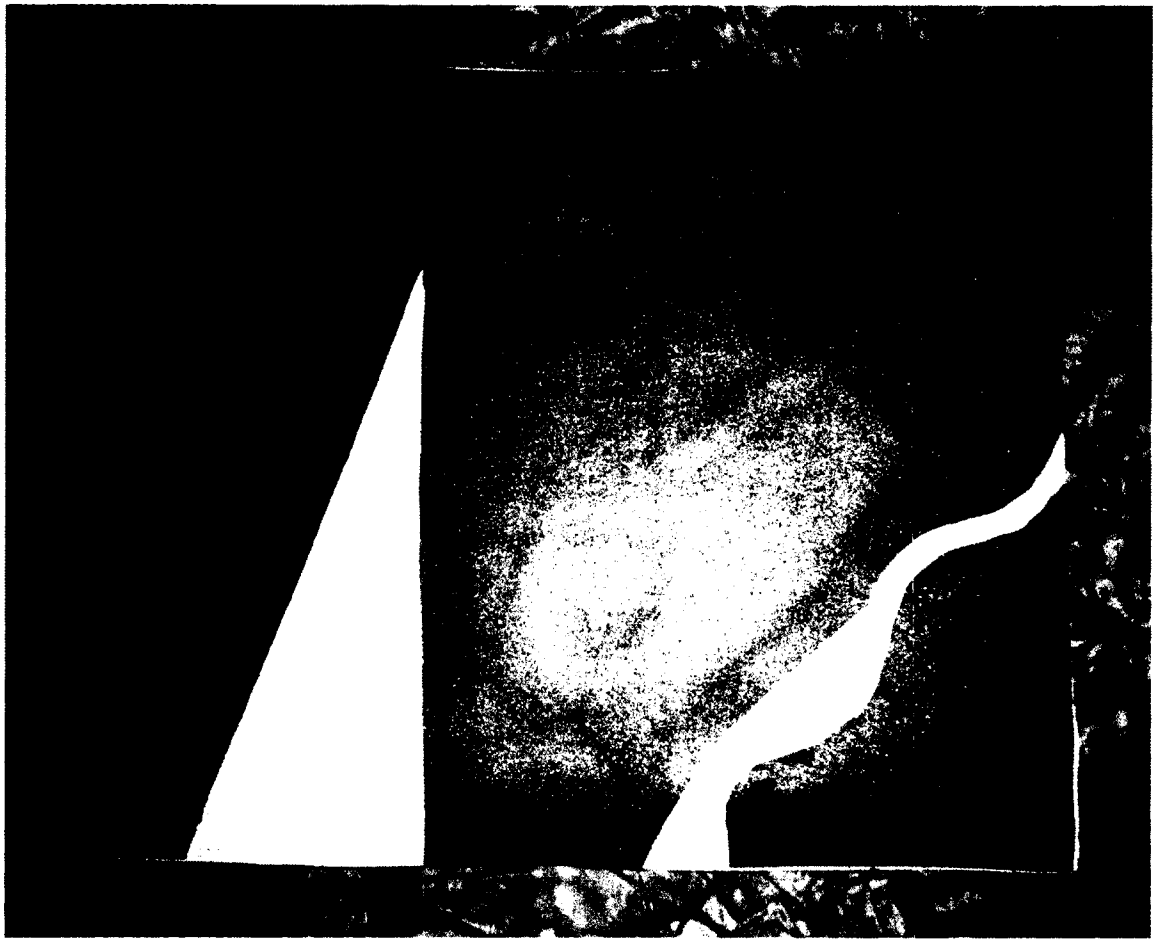

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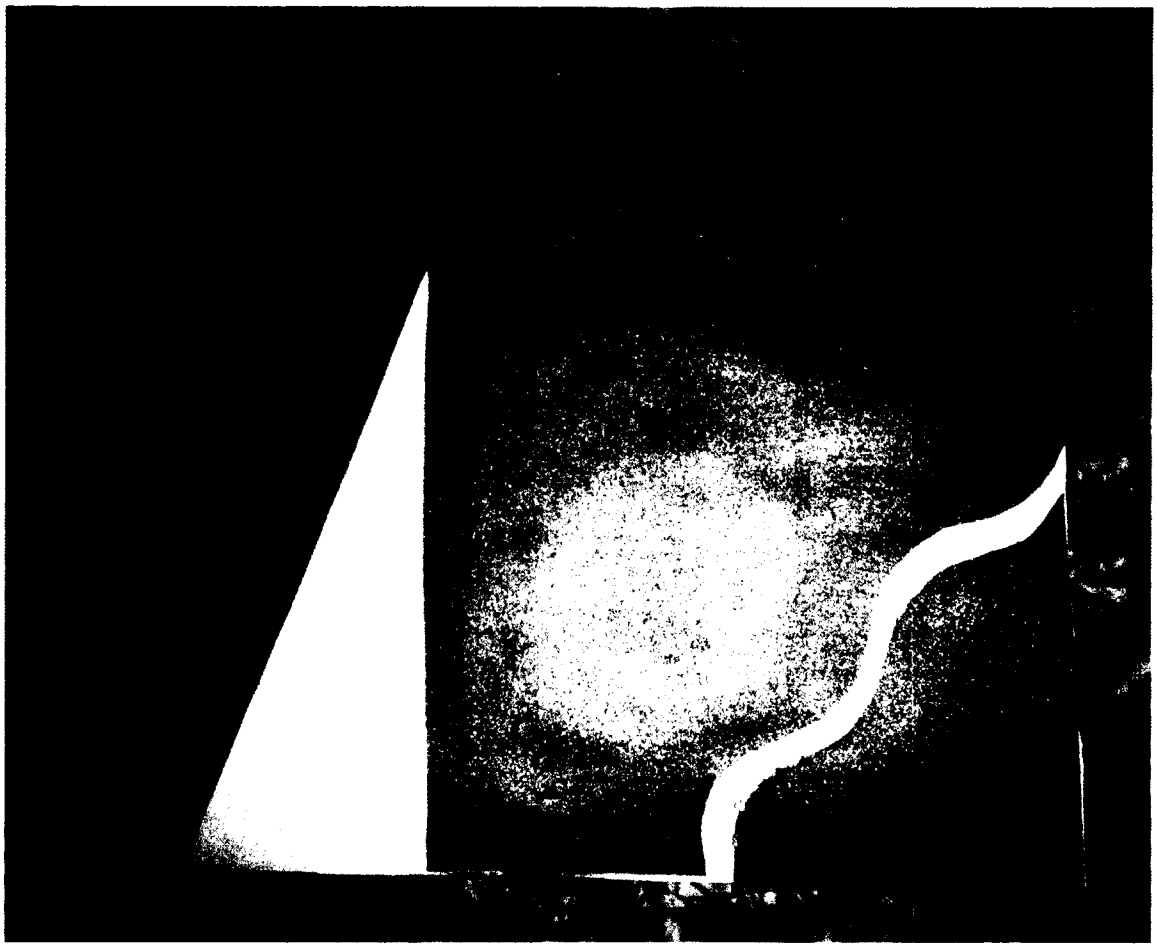

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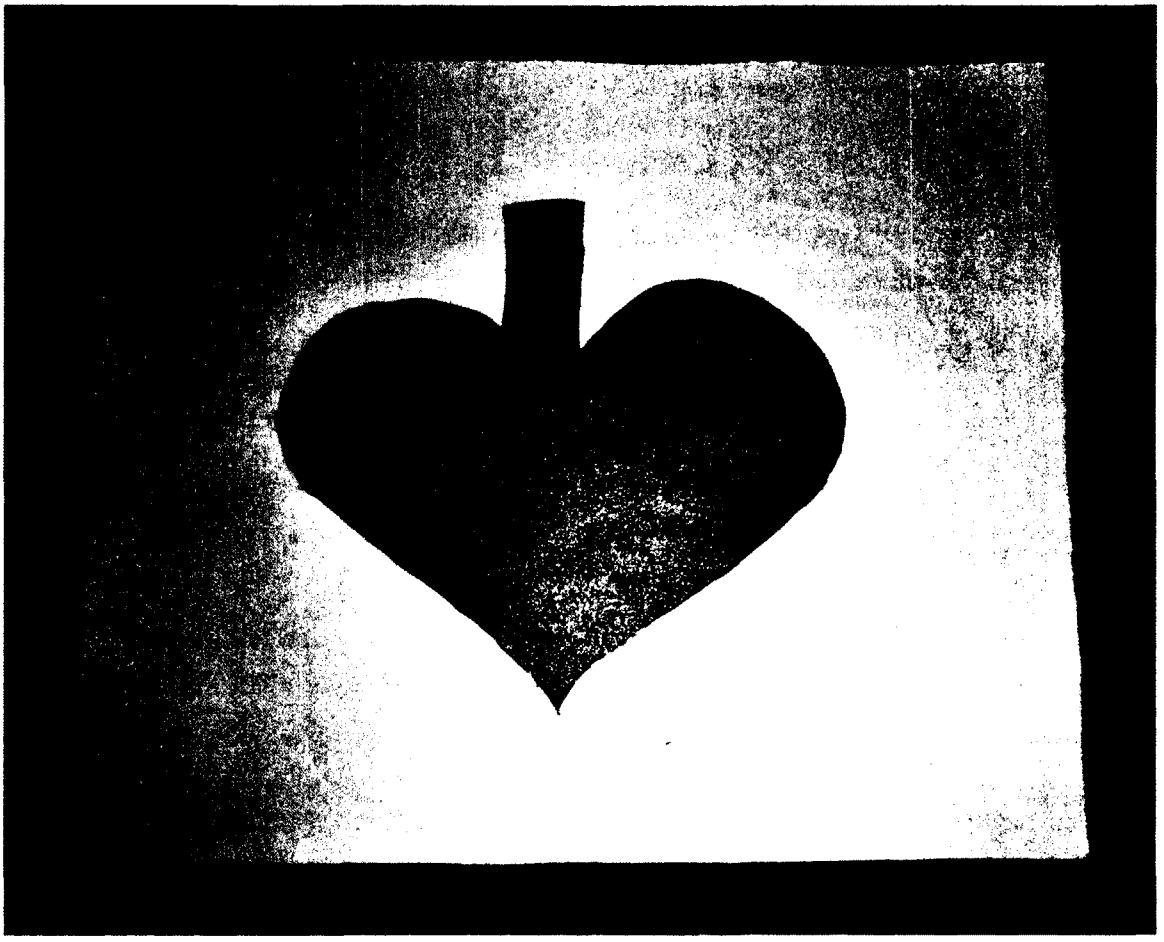

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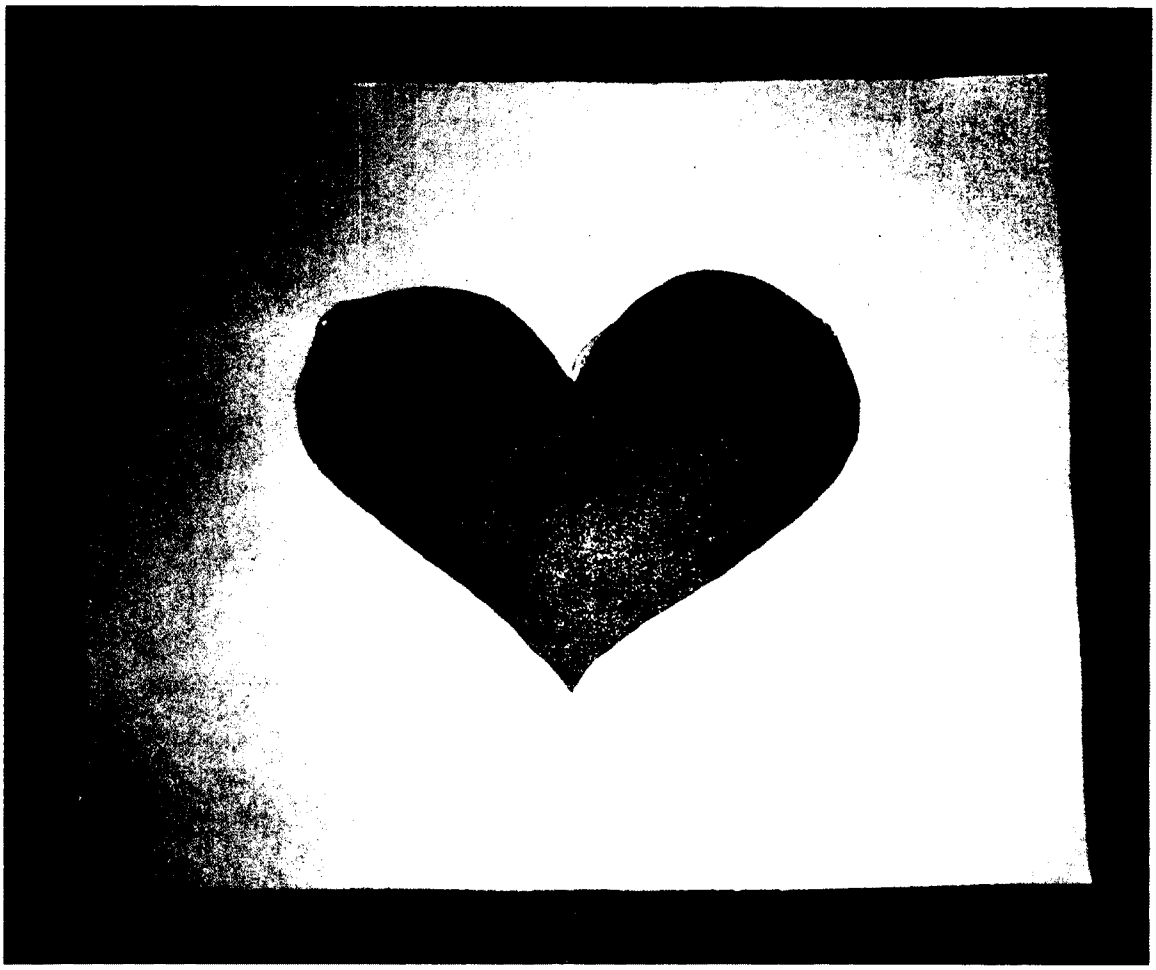

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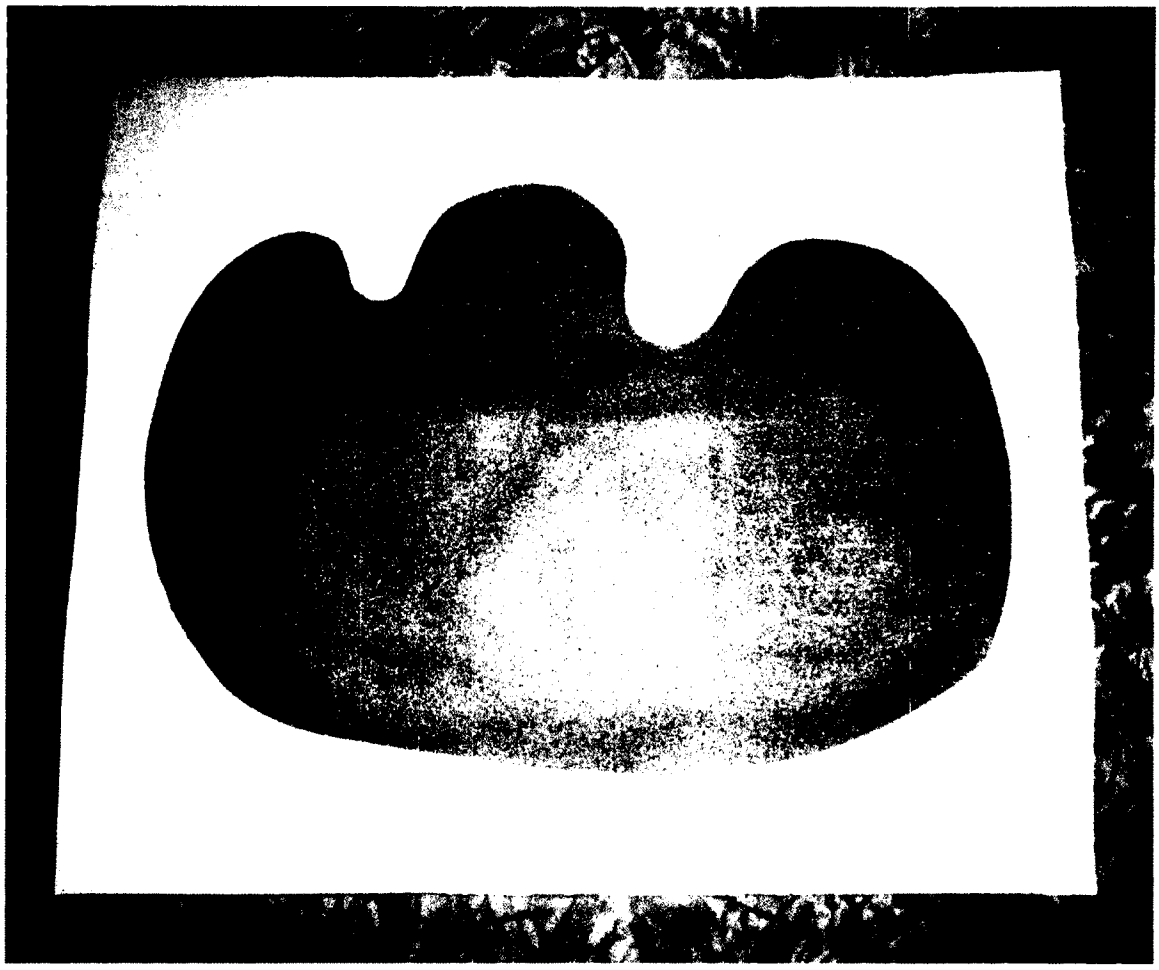

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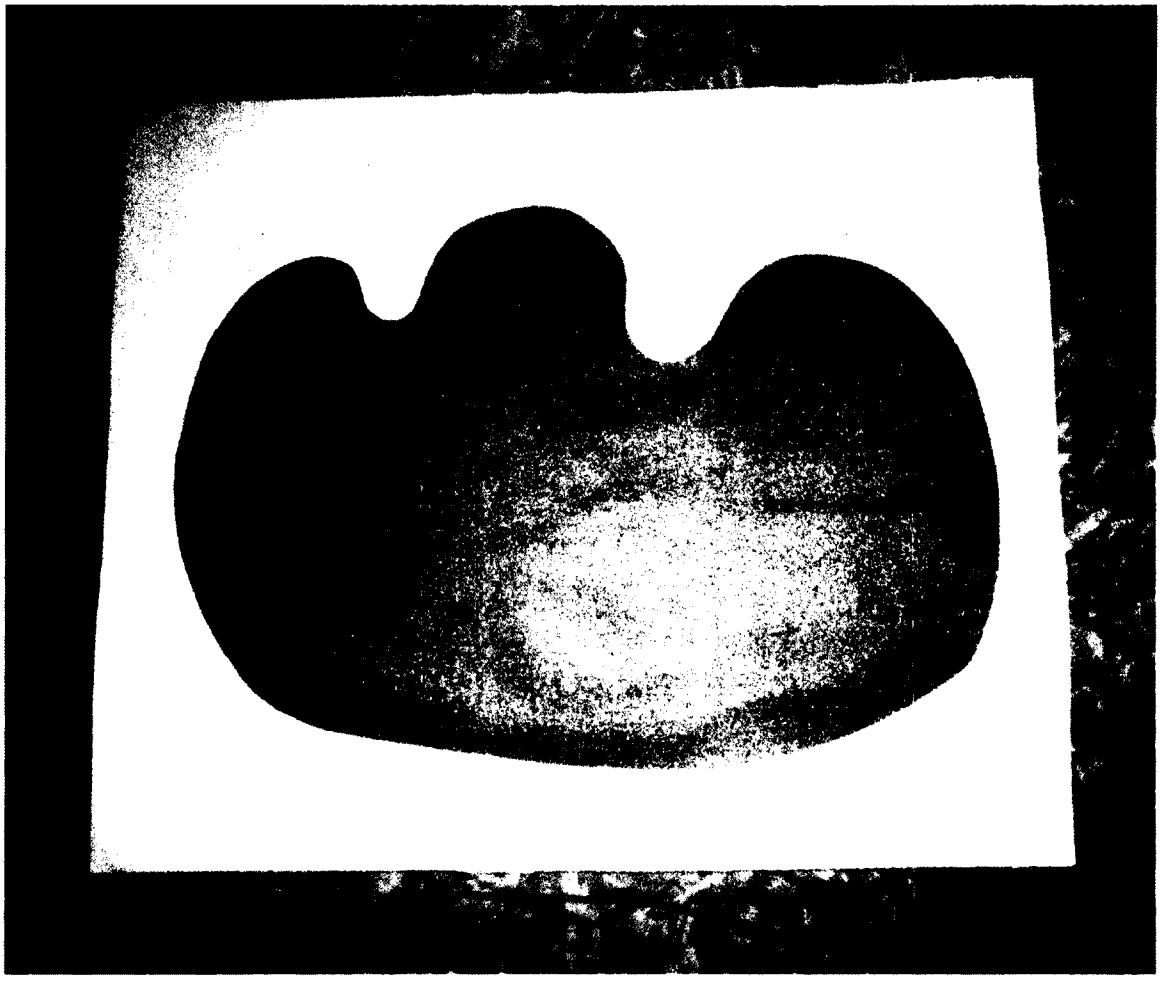

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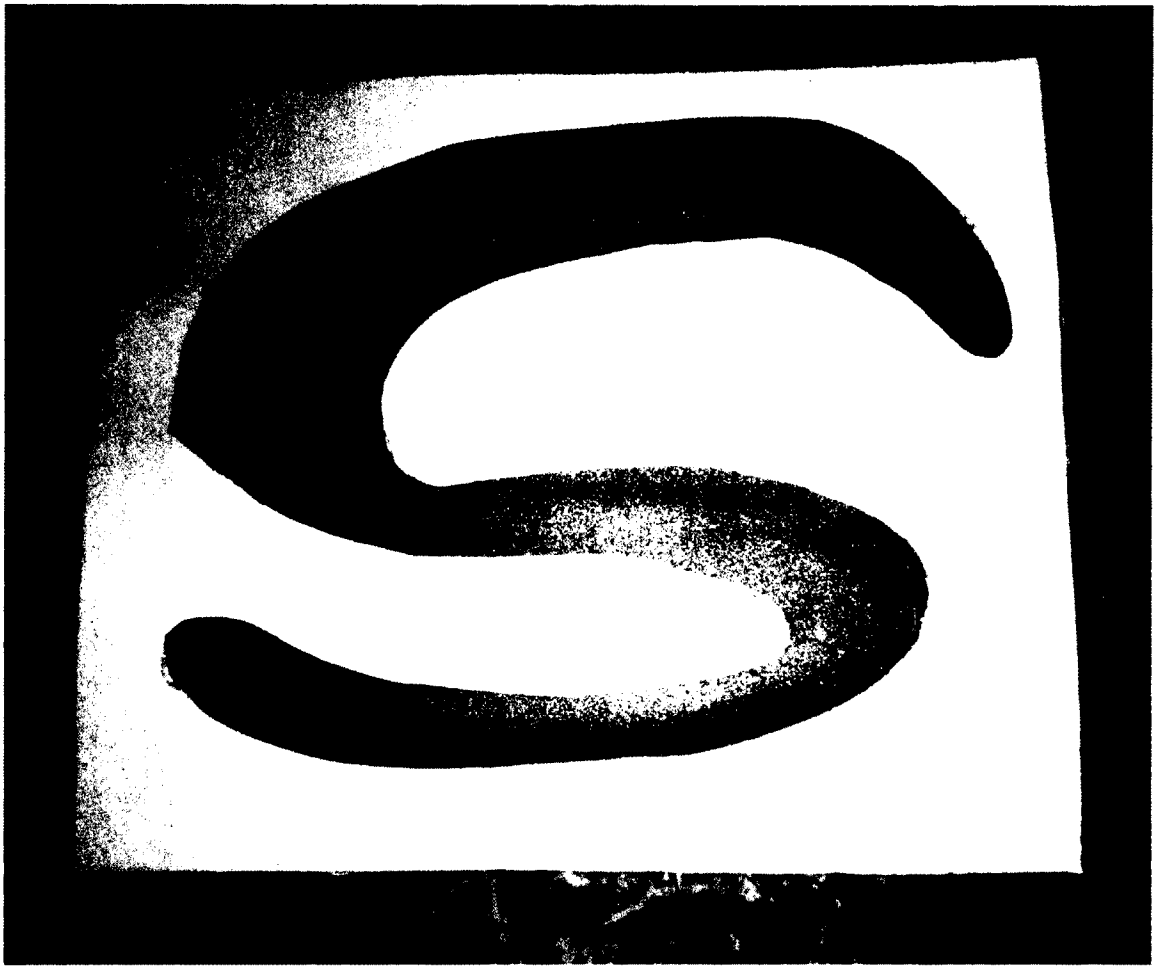

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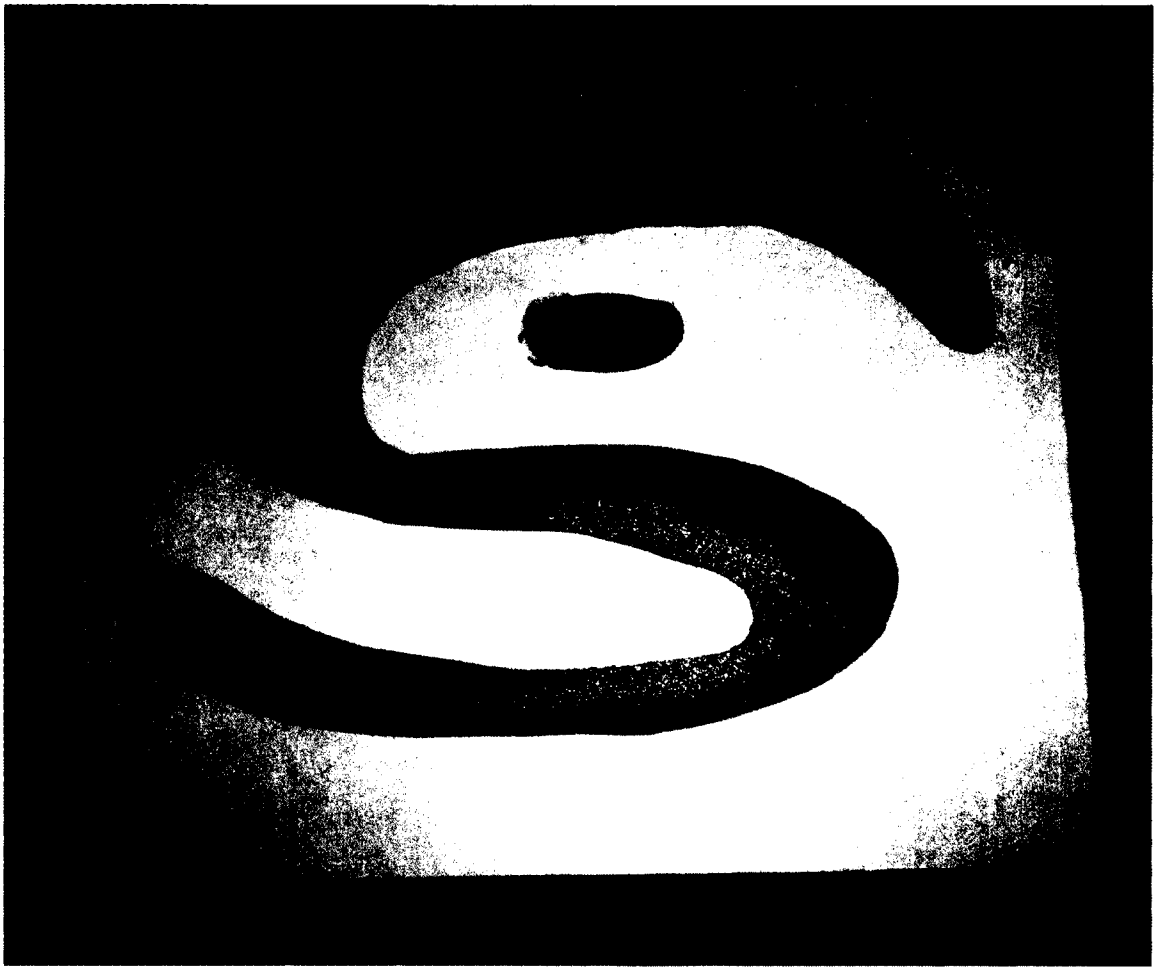

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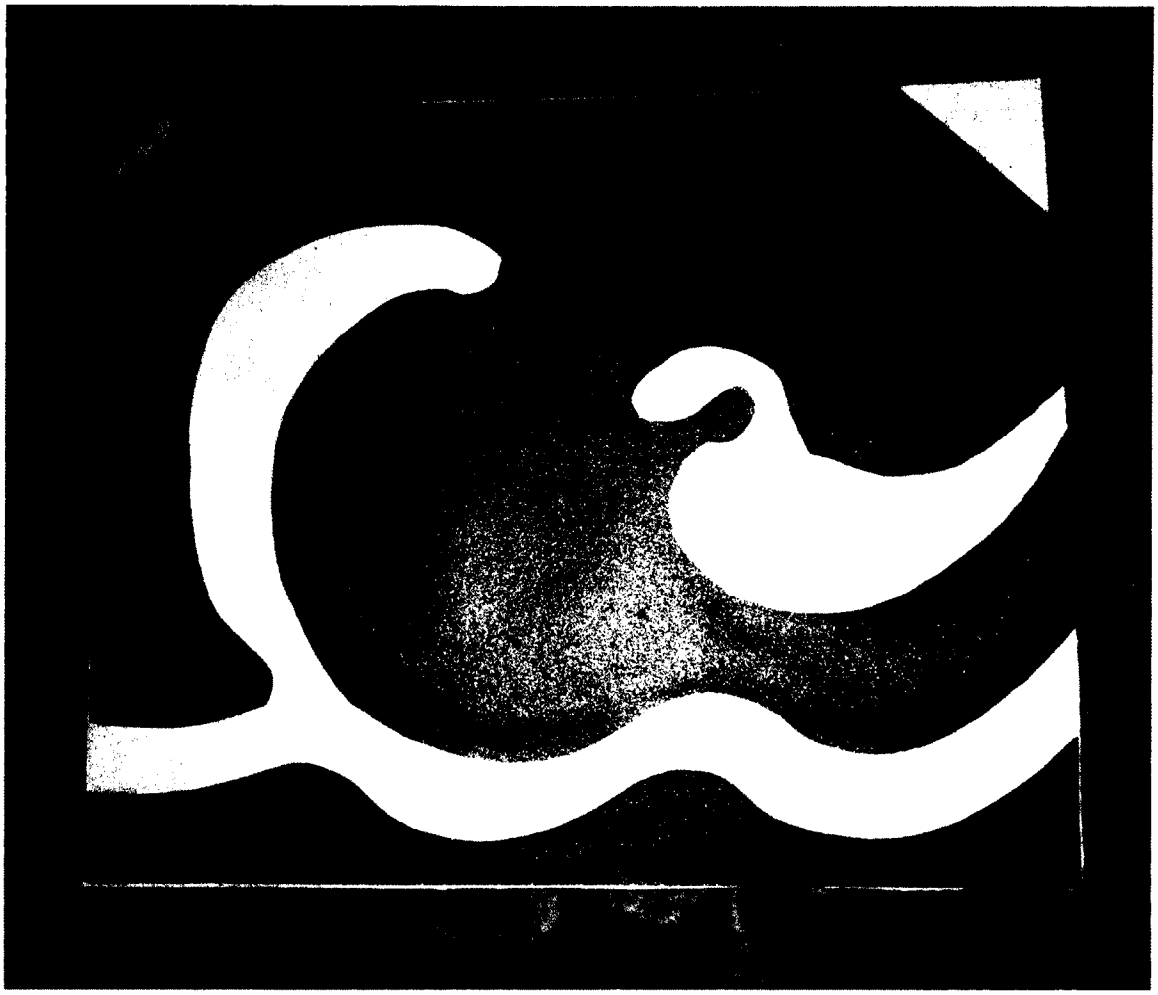

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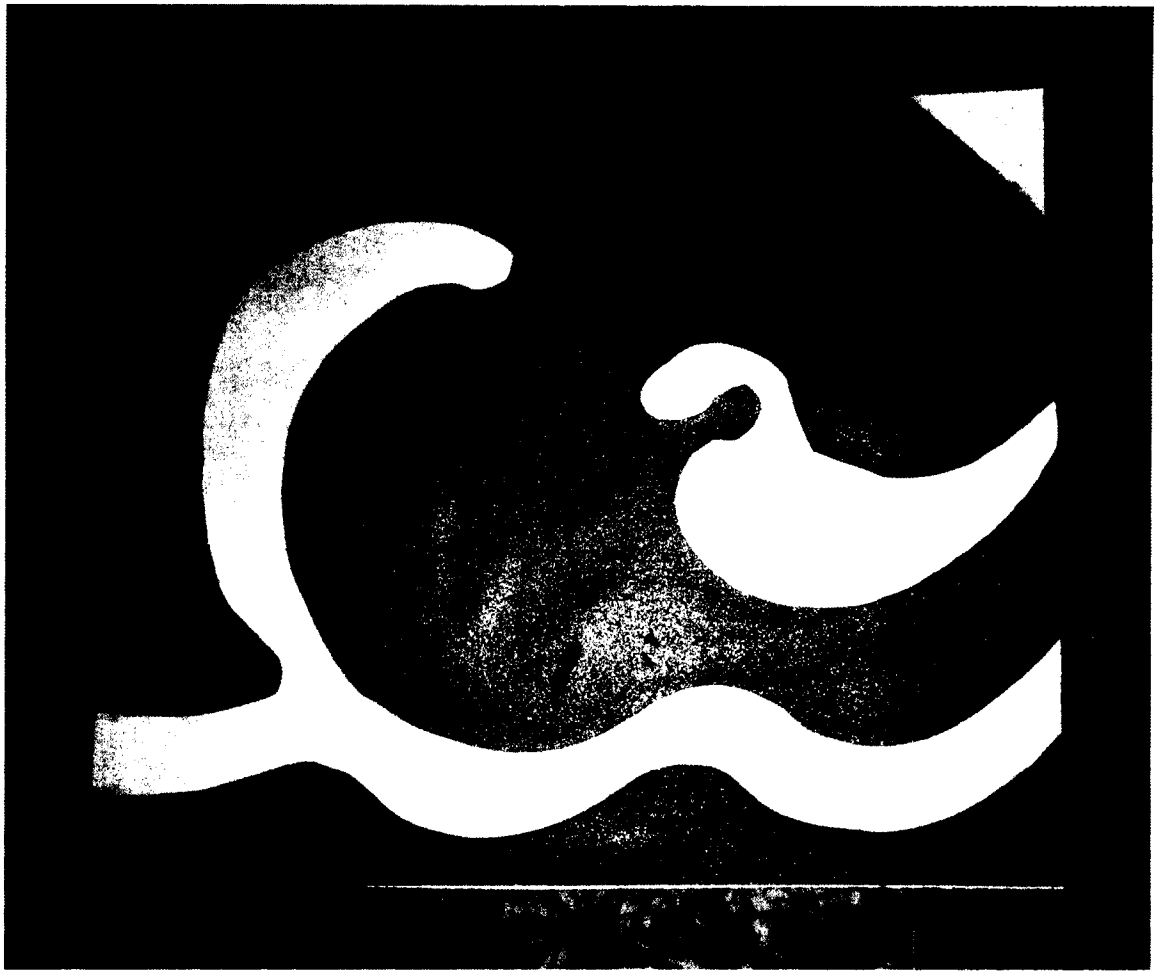
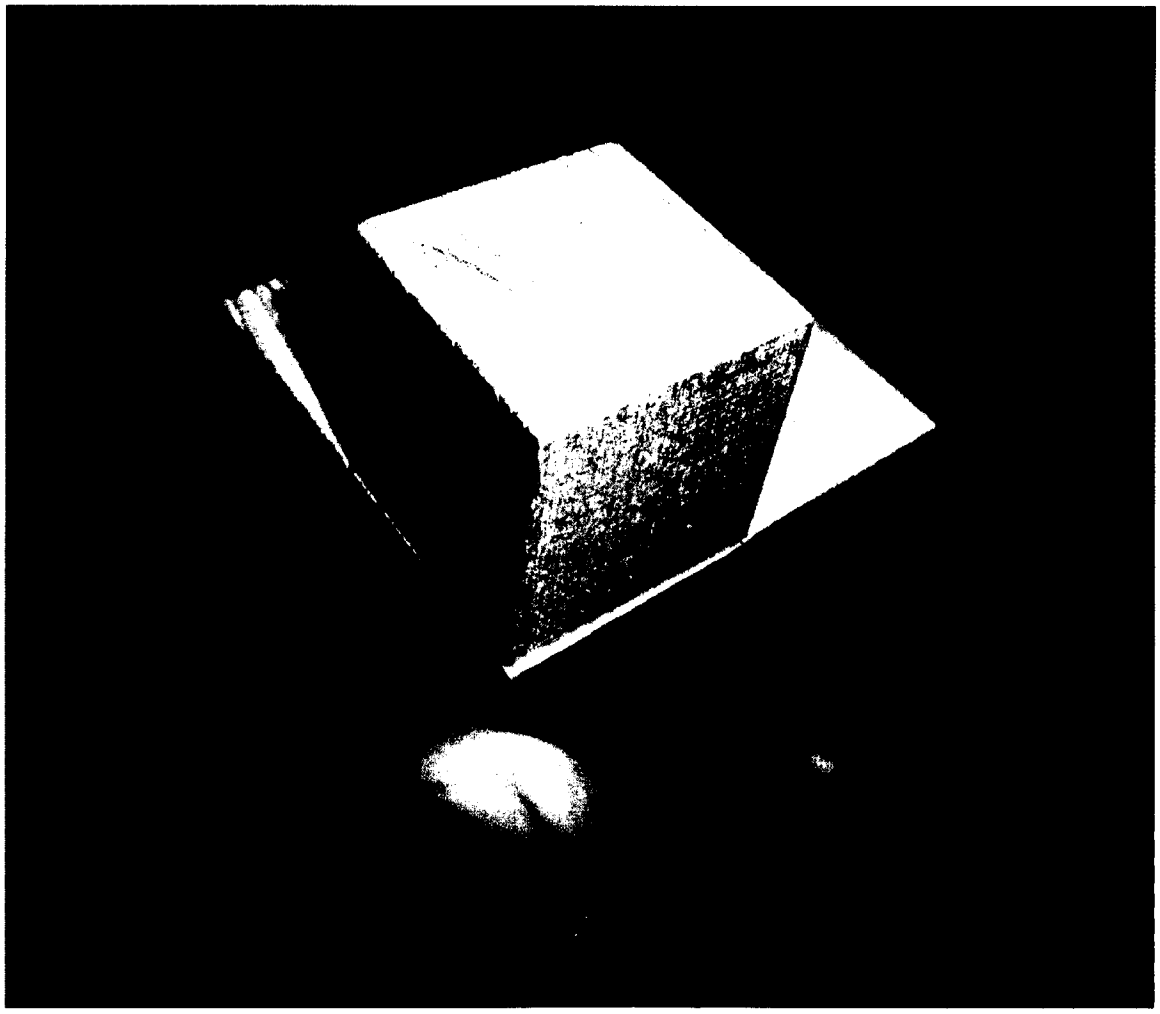


Tactile Figure-Ground Identification

APPENDIX D

TACTILE BLOCK CONFIGURATIONS



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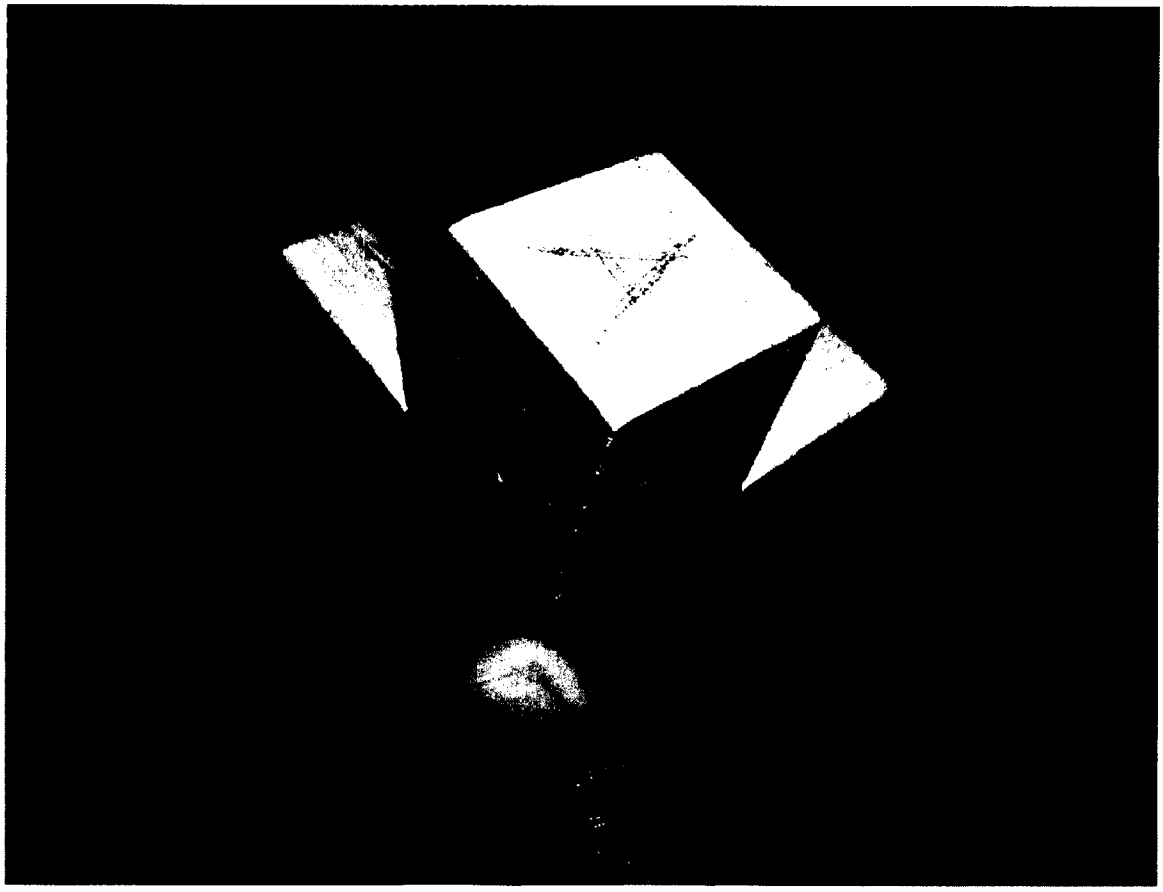

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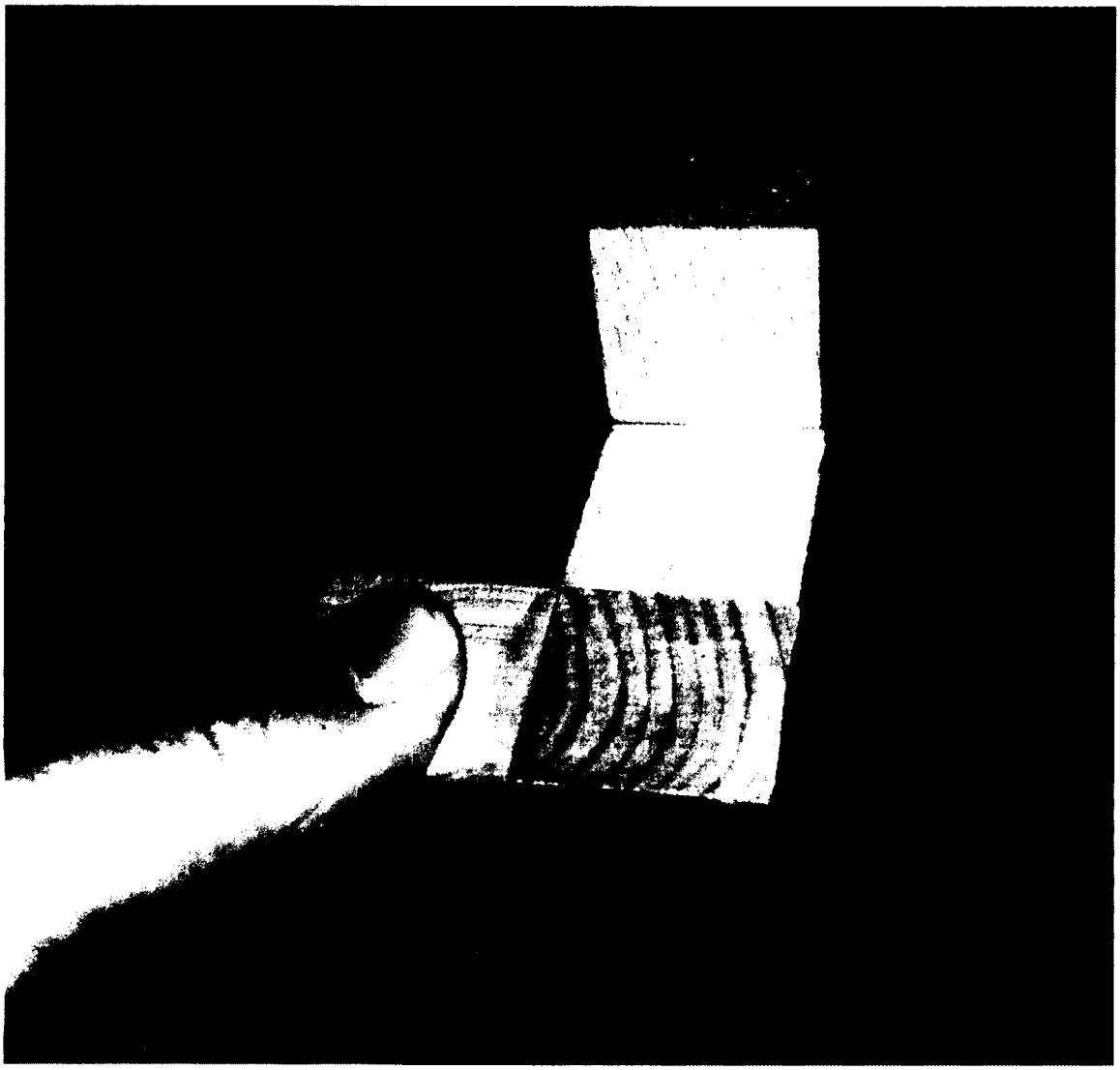

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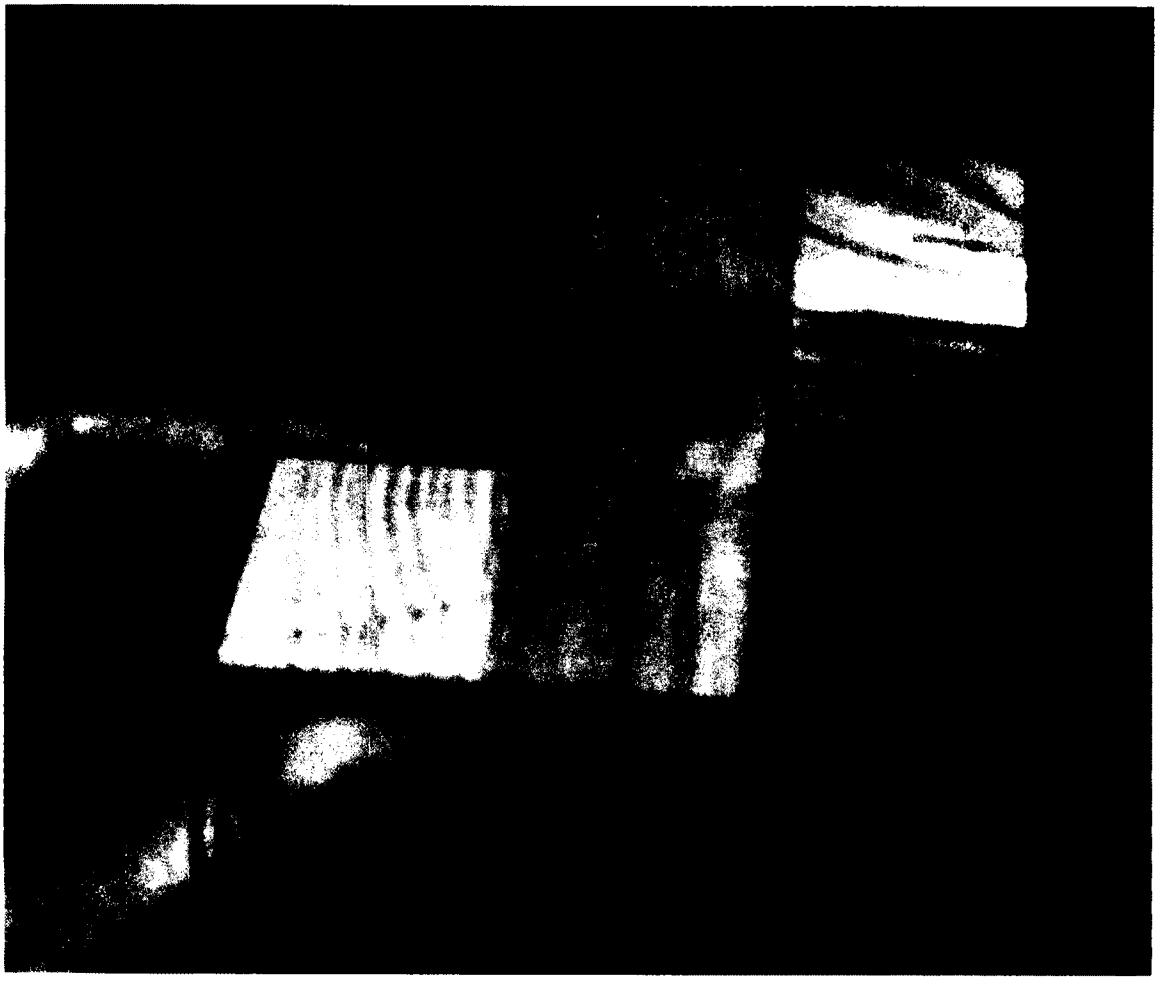

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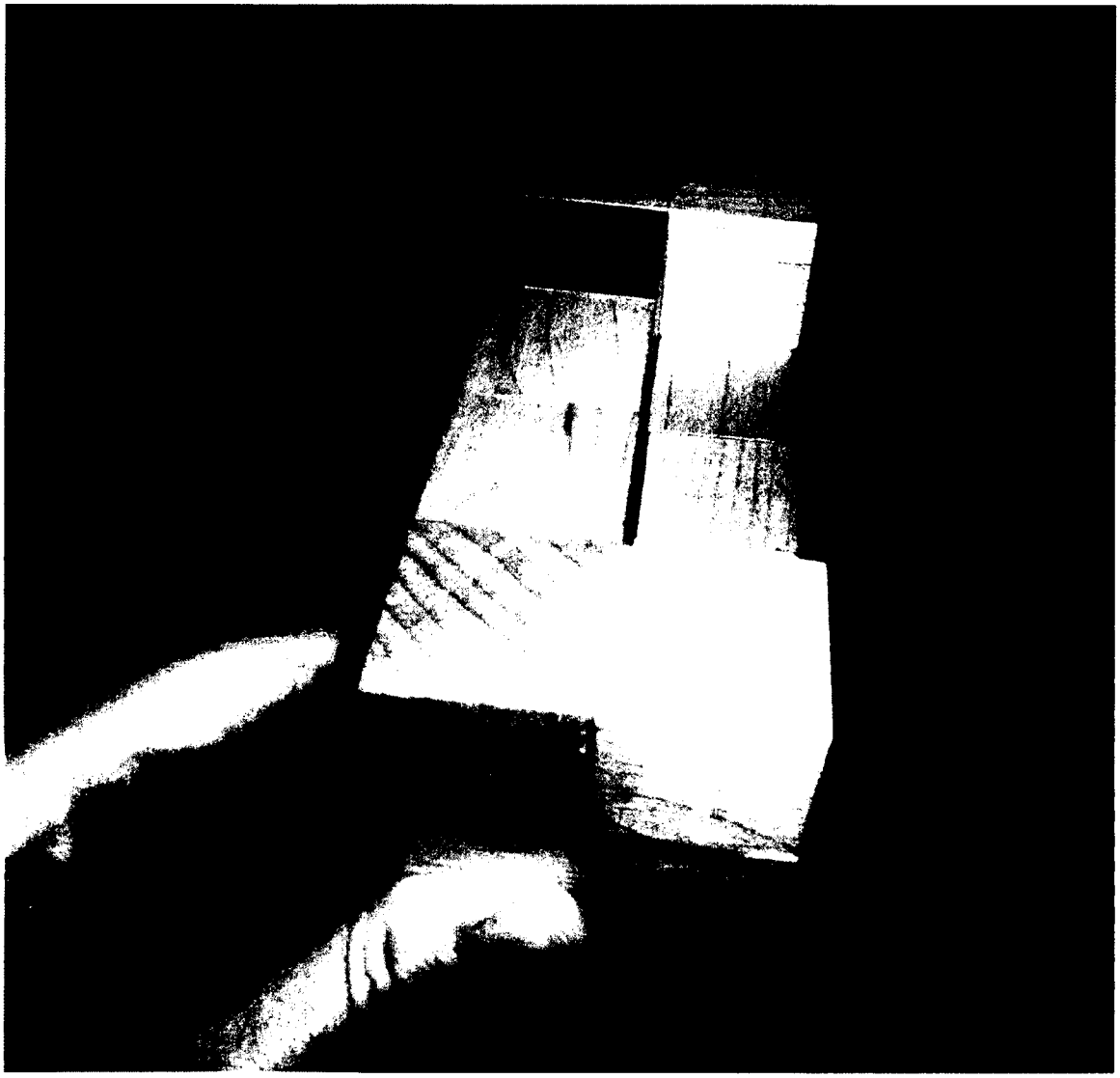

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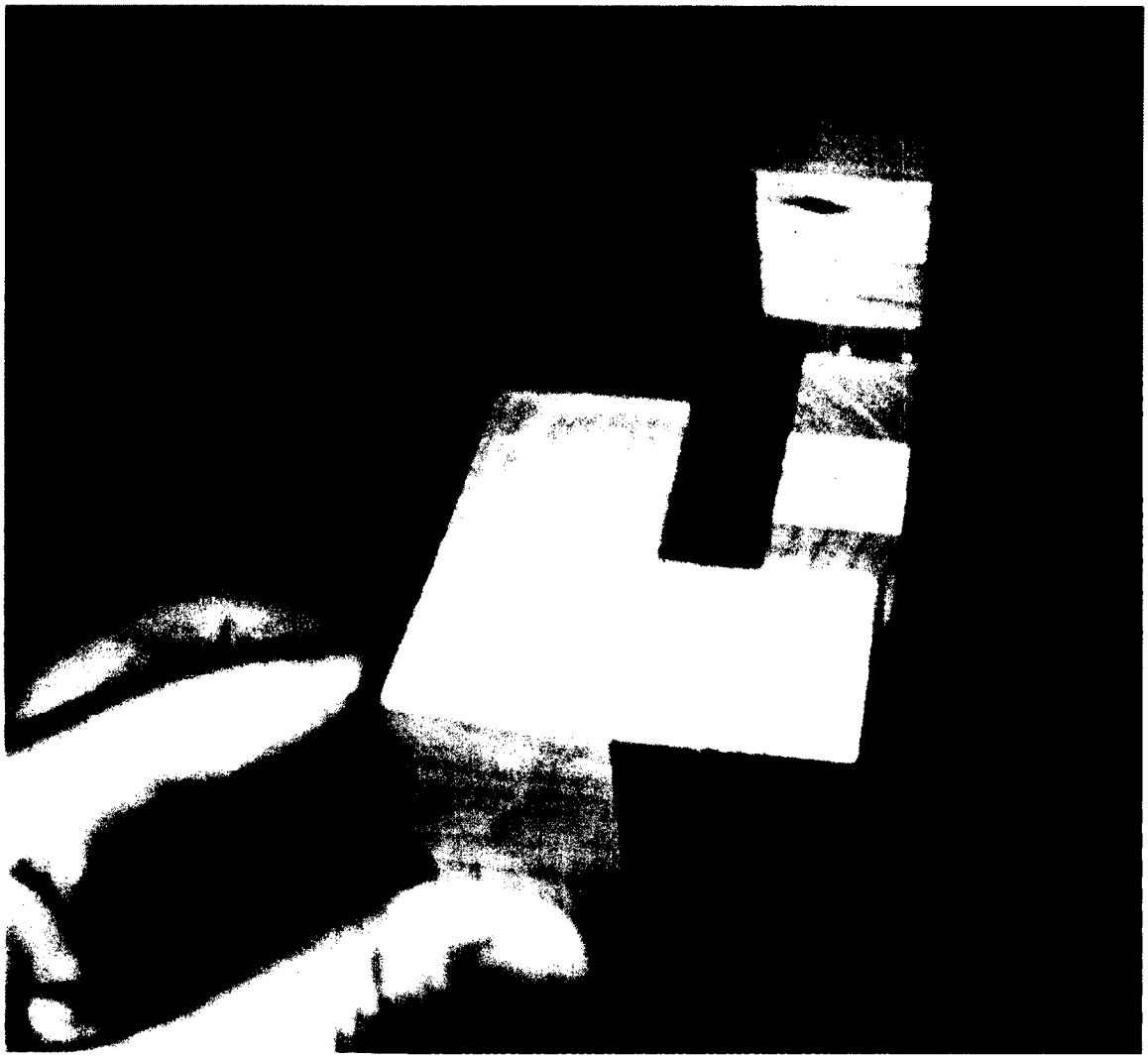

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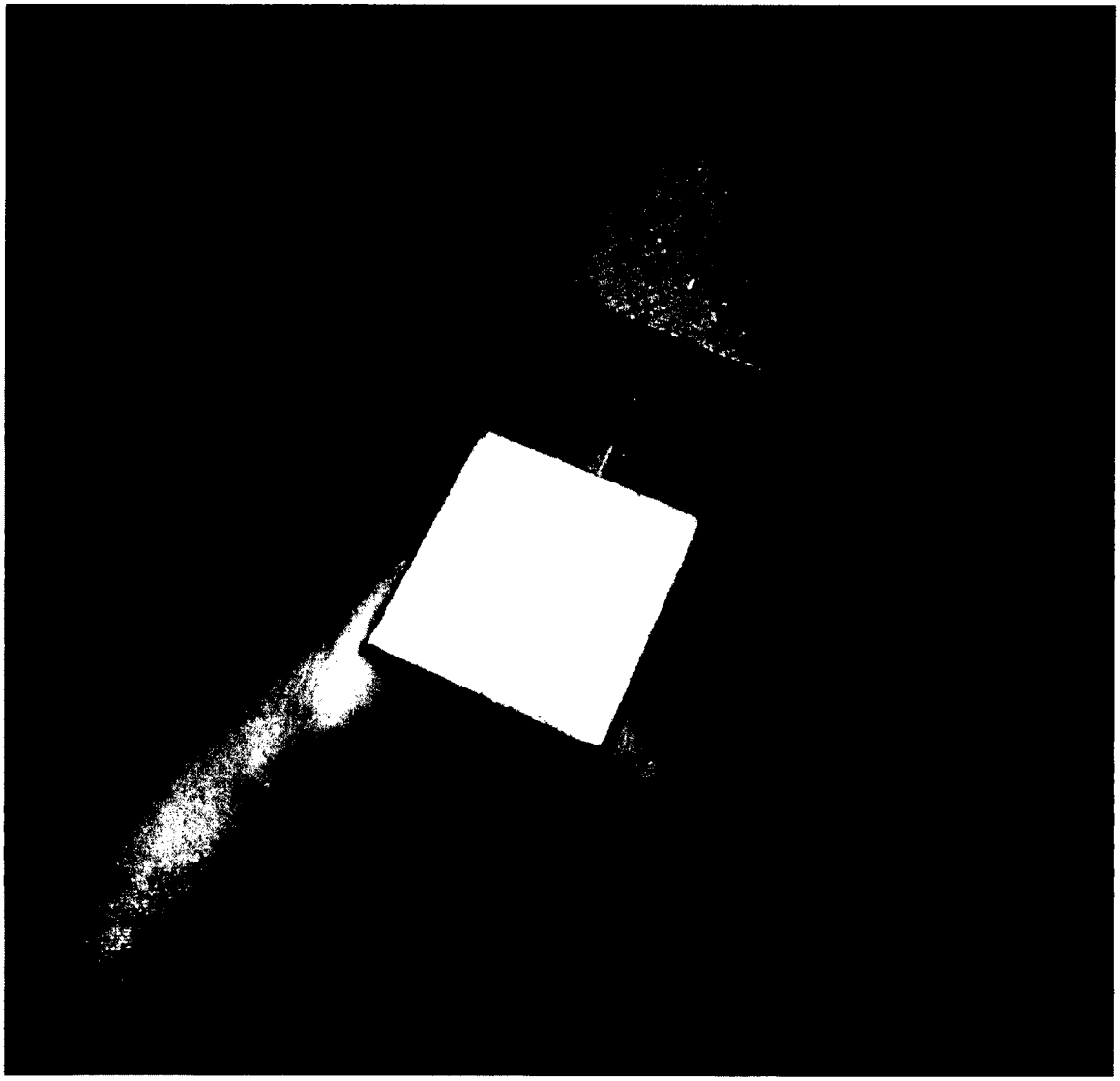

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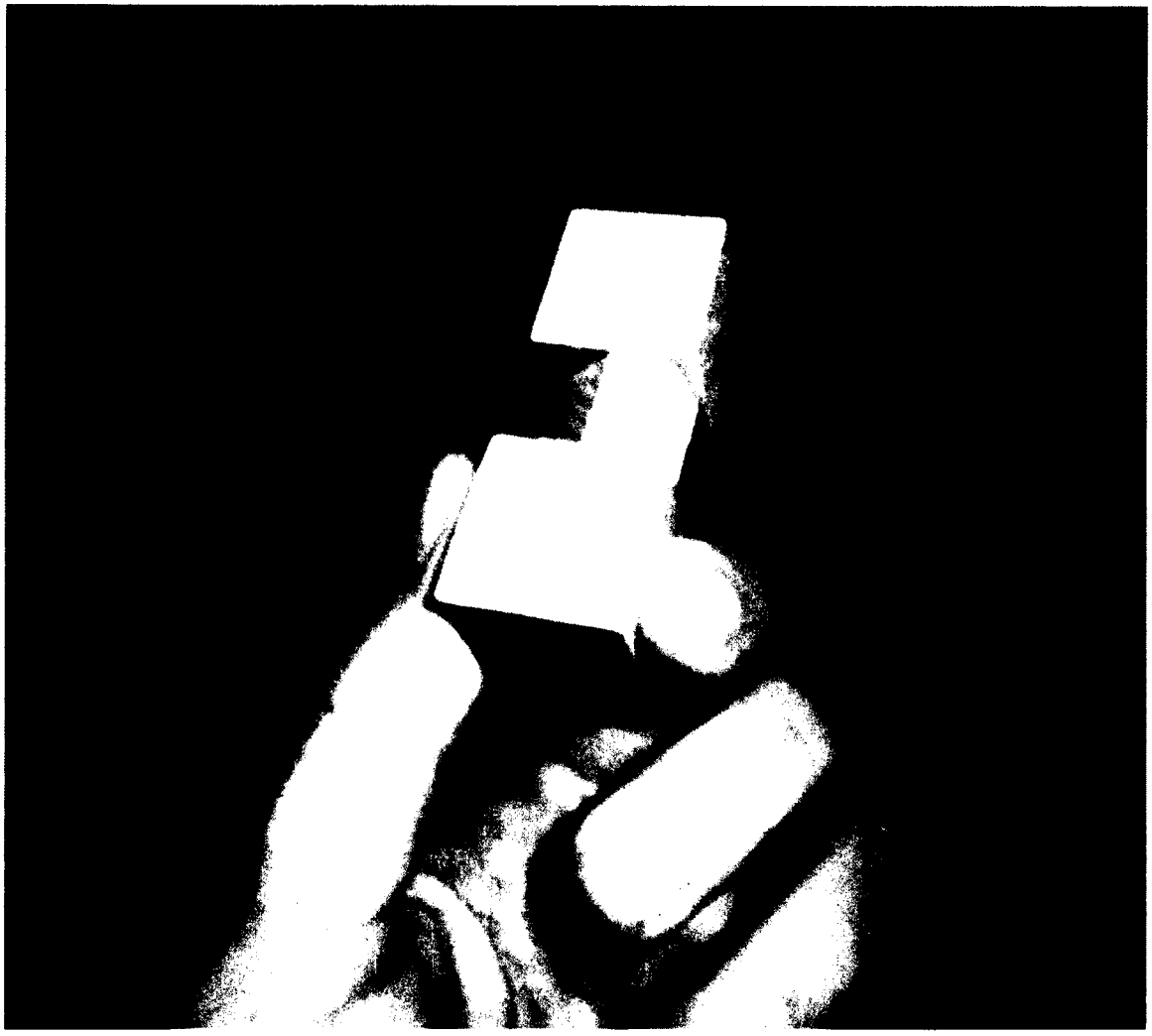

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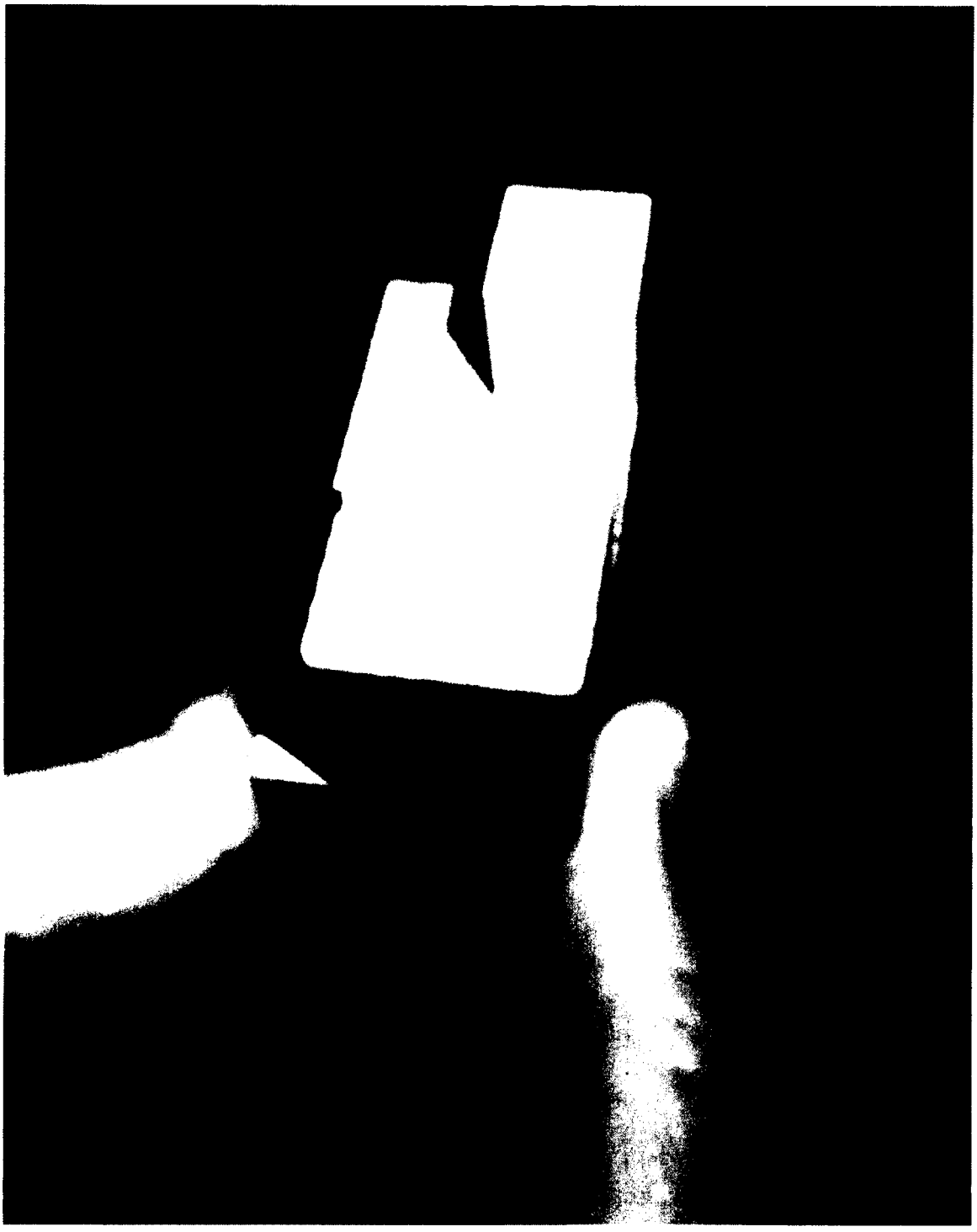

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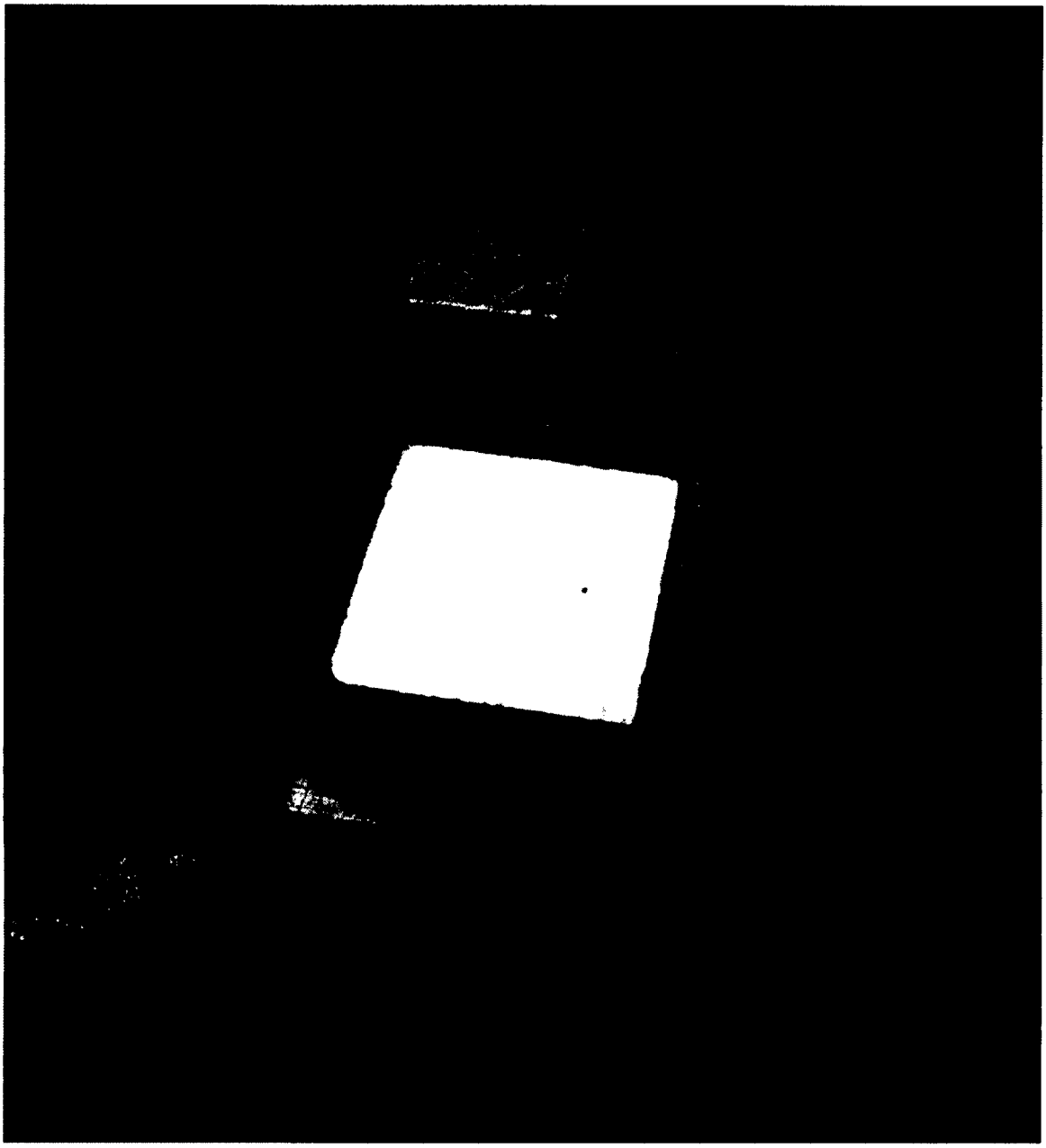

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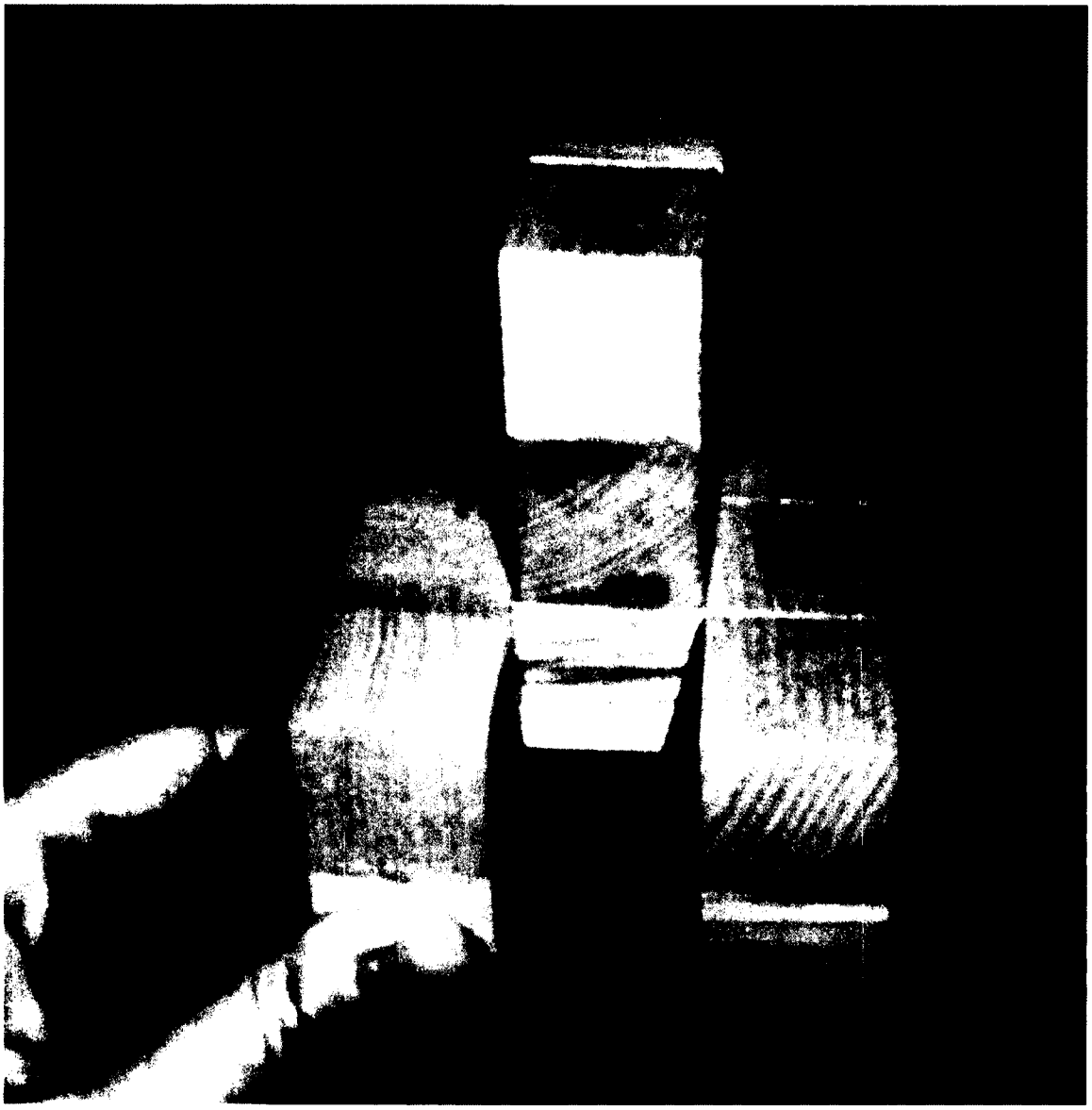

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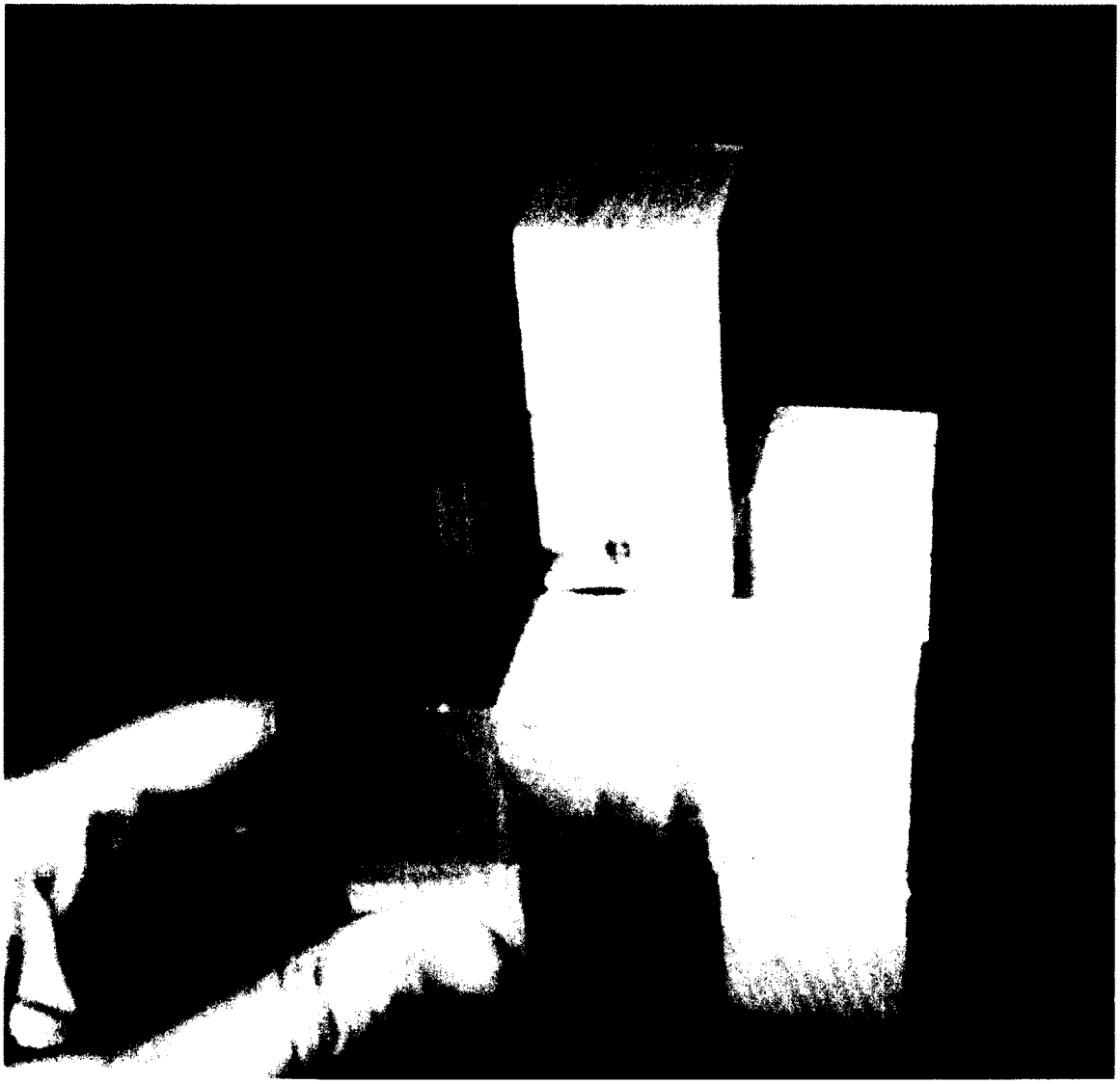
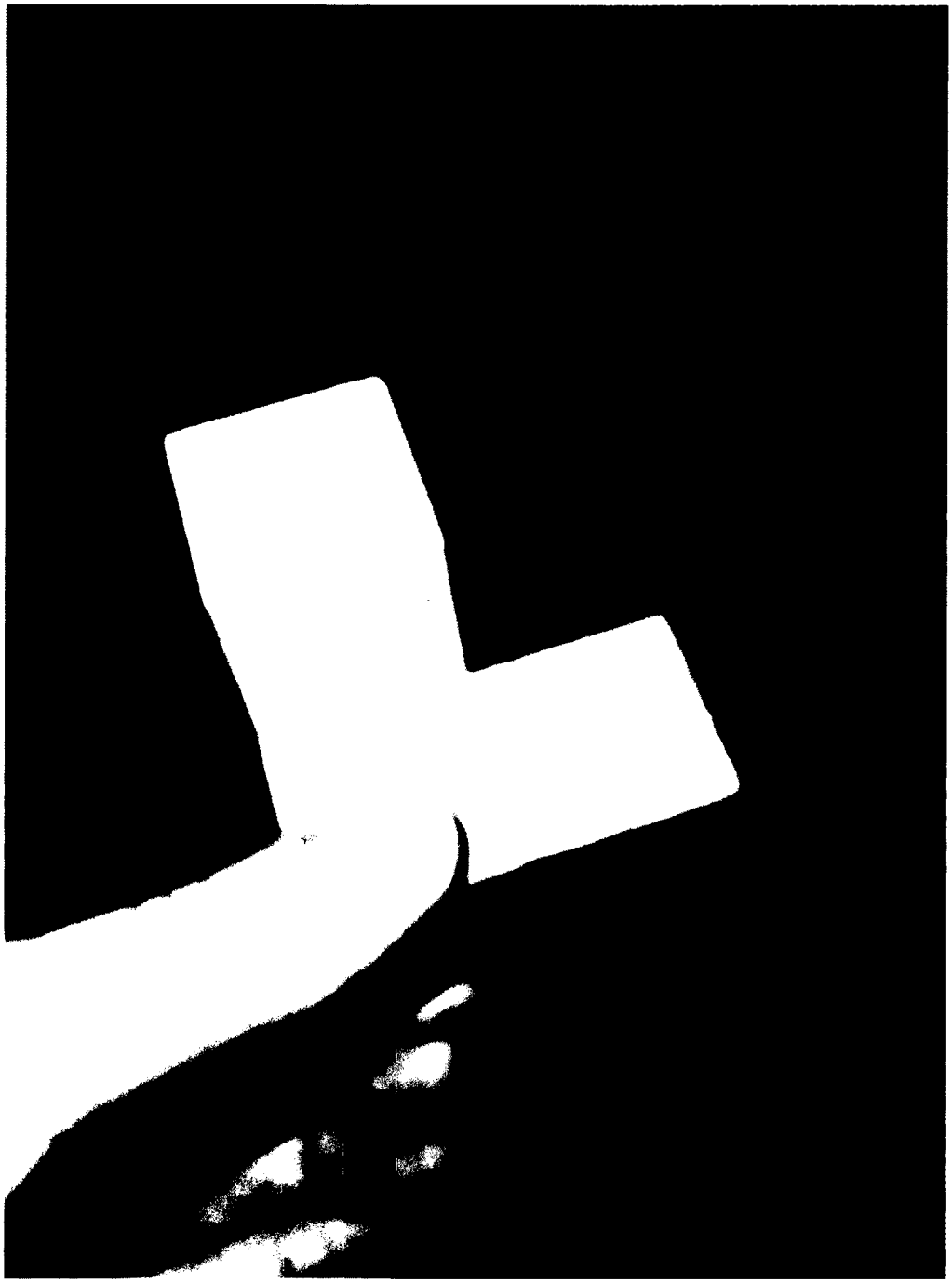


Tactile Block Configurations

Tactile Block Configurations

Tactile Block Configurations



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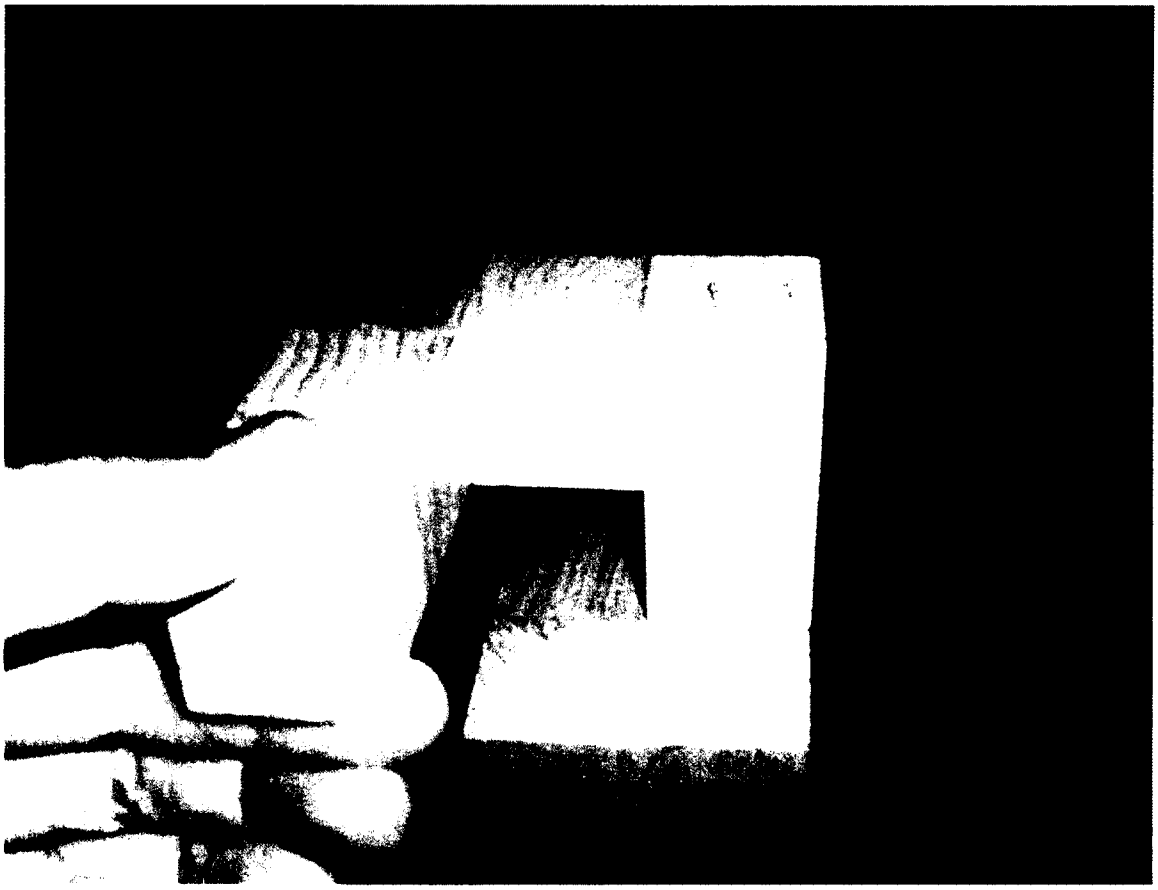
Tactile Block Configurations



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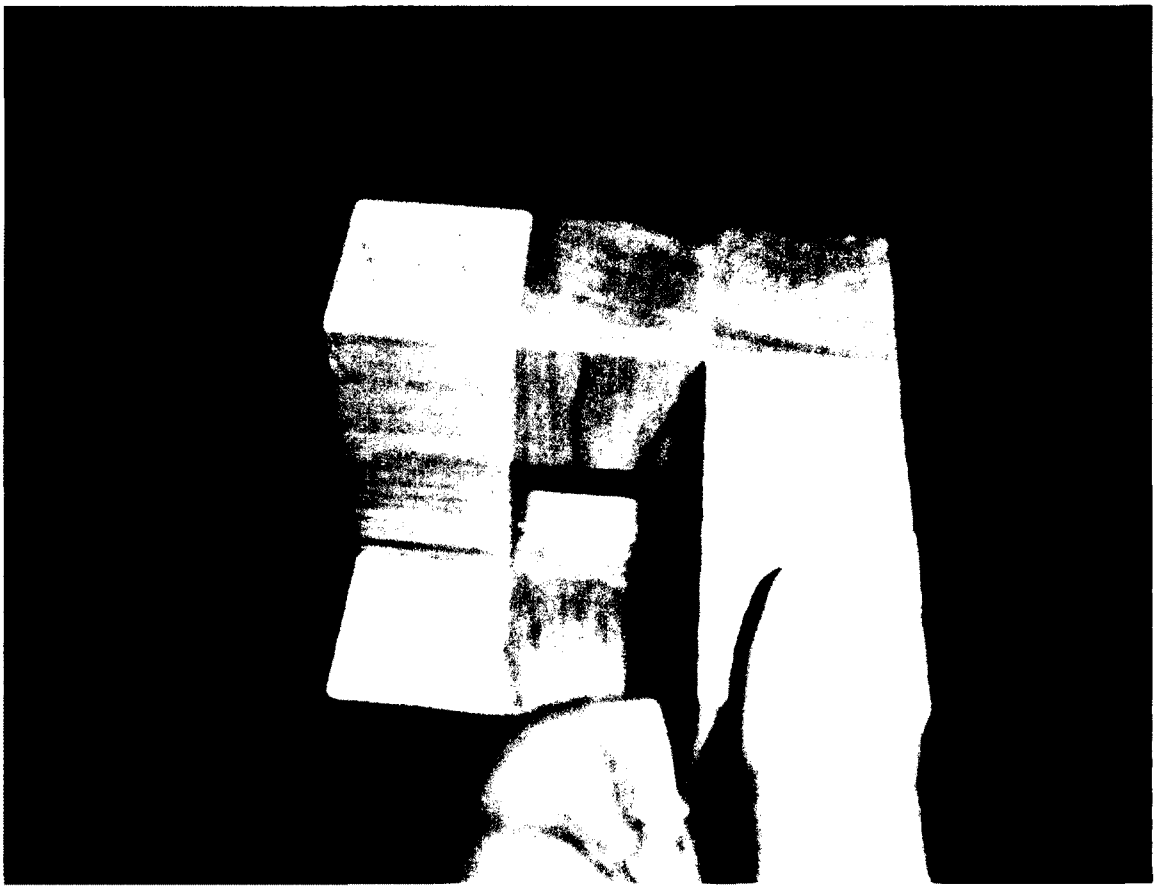

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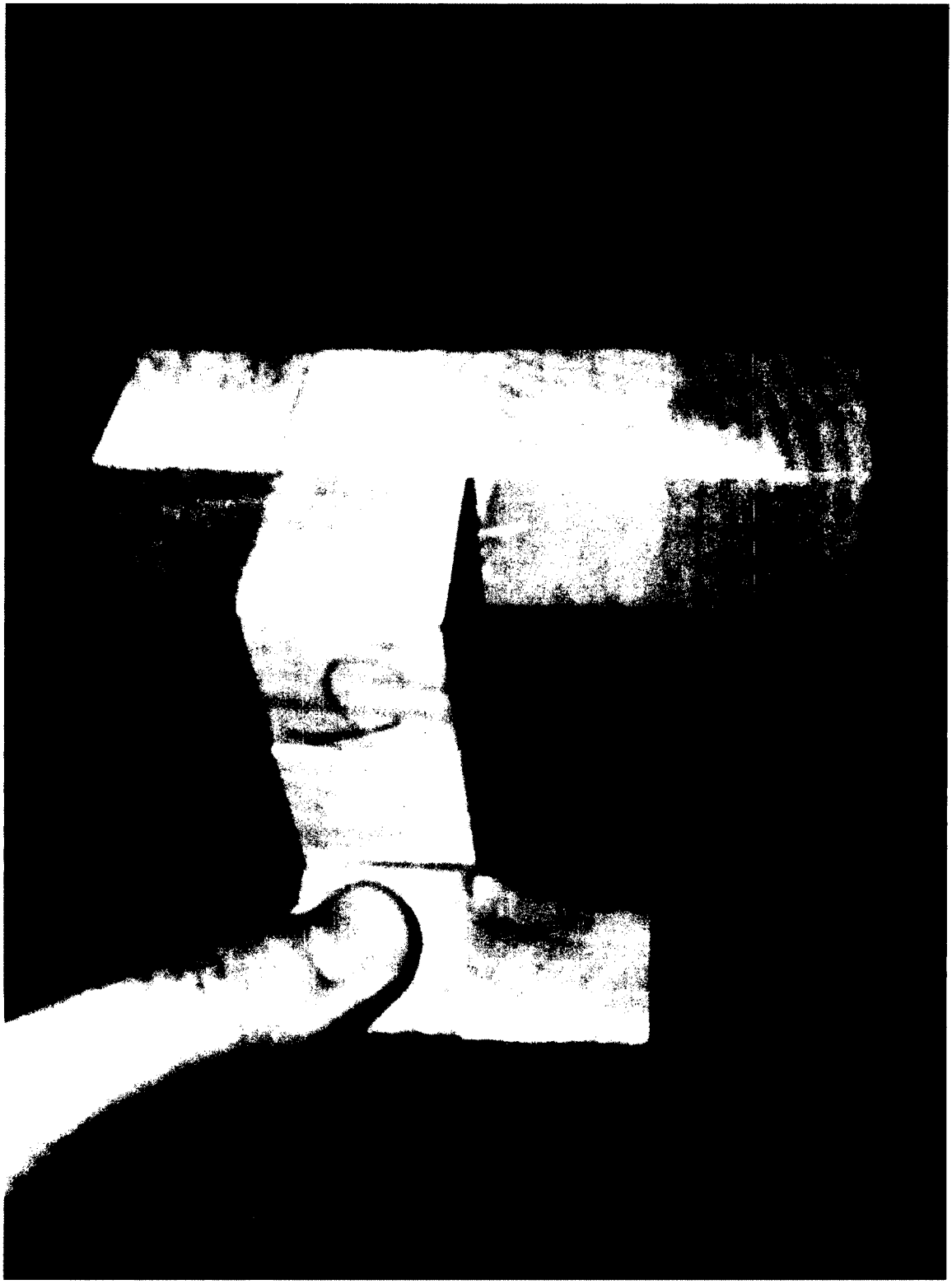

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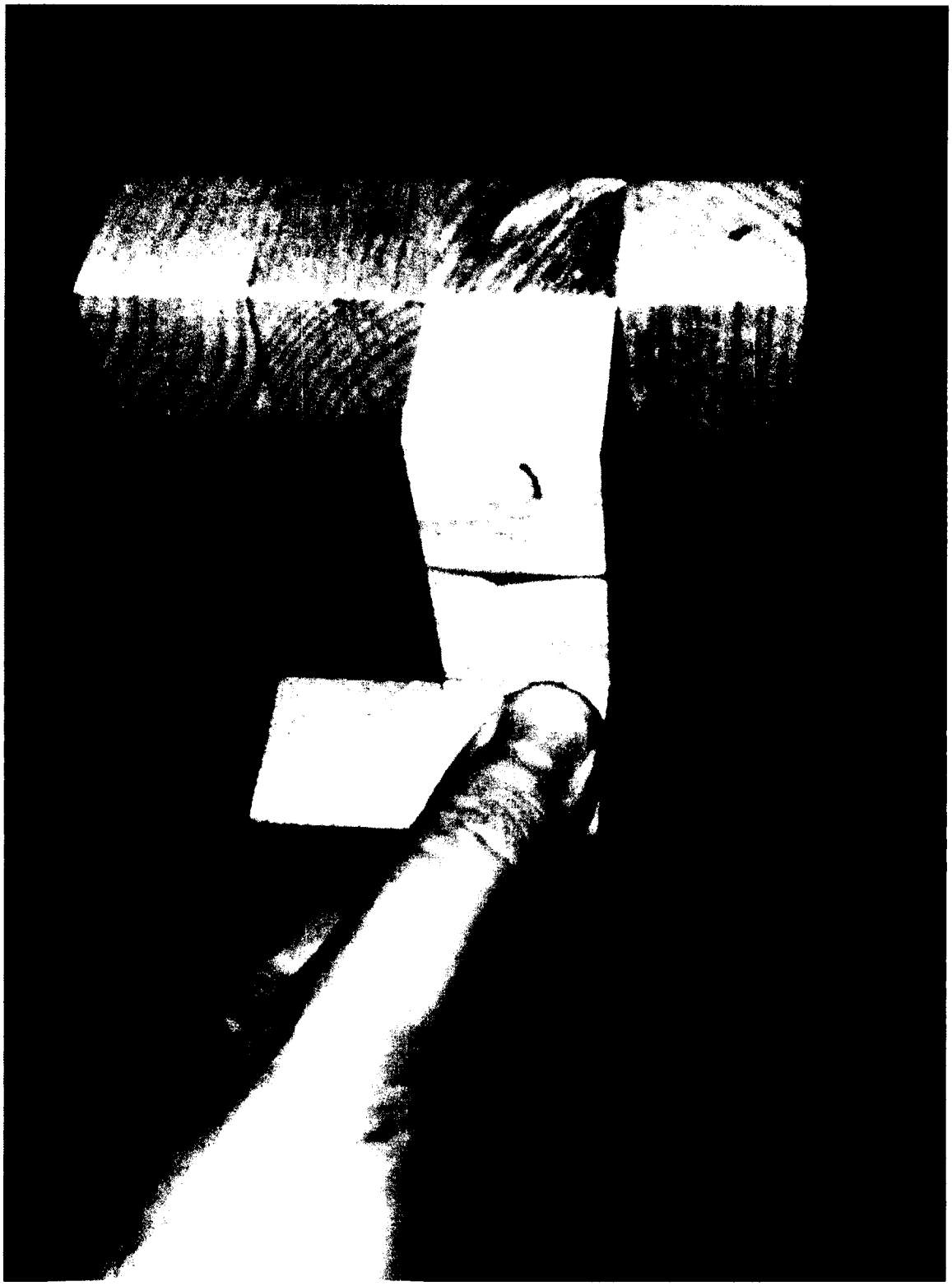

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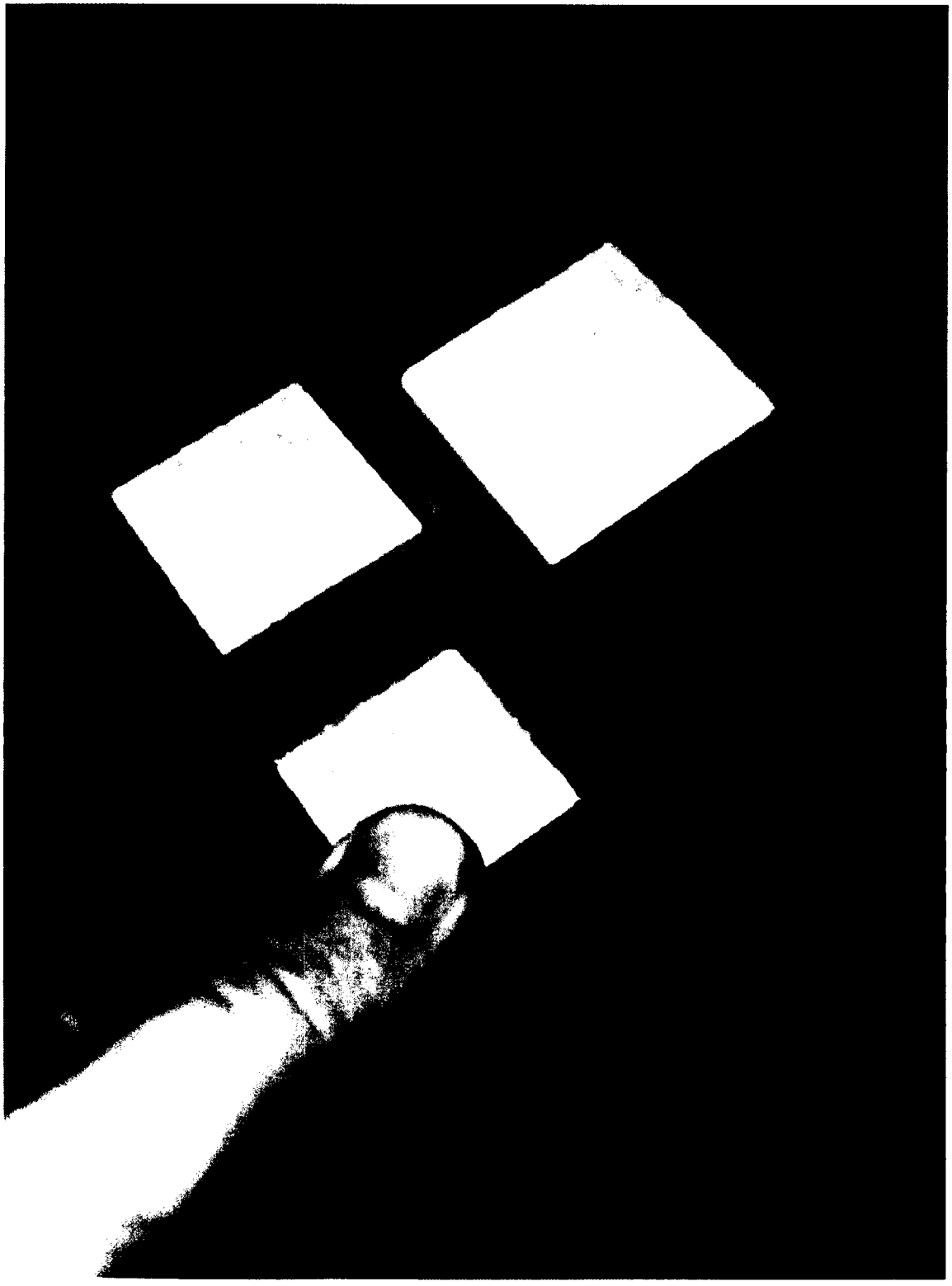
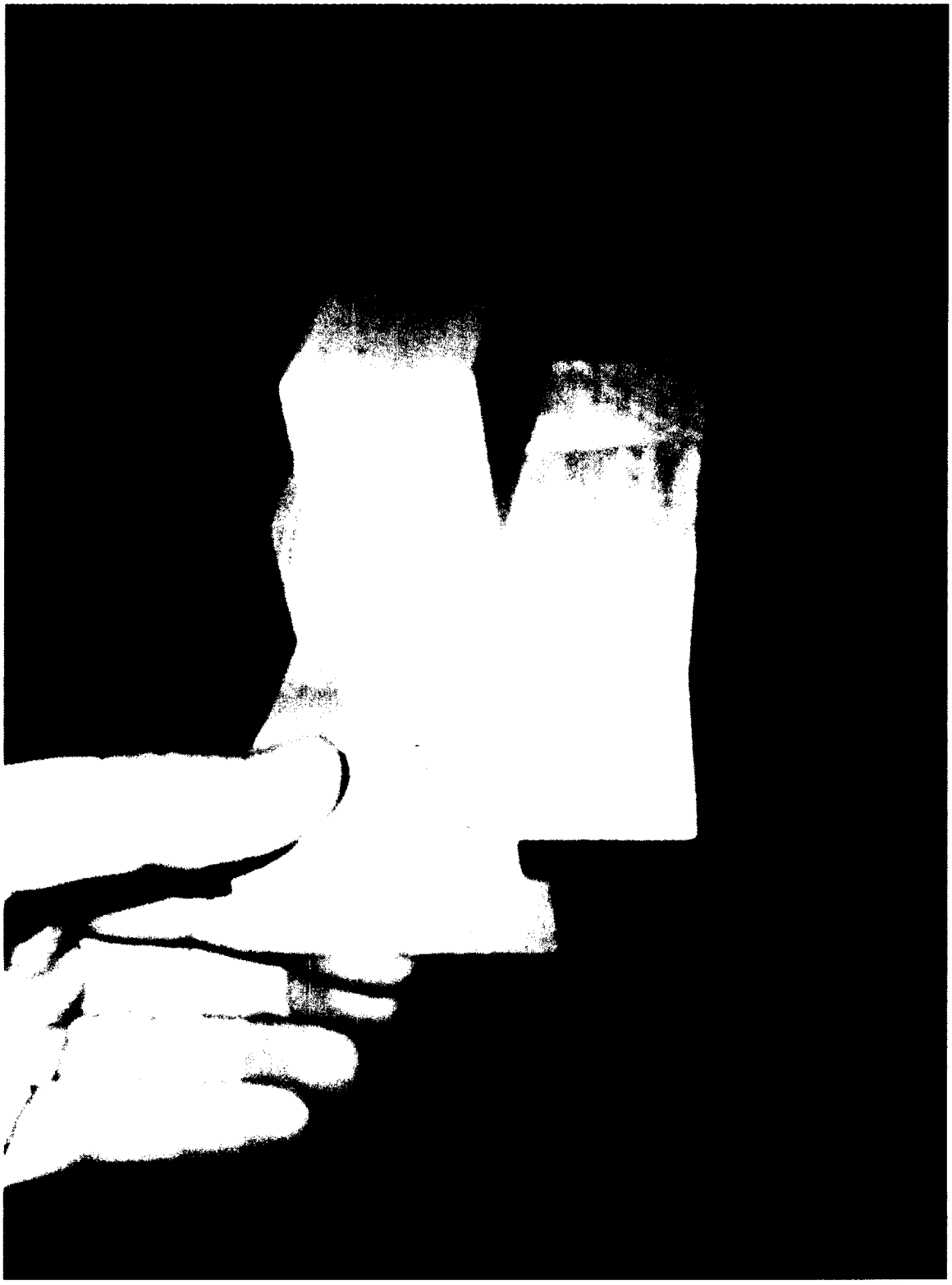


Tactile Block Configurations

Tactile Block Configurations



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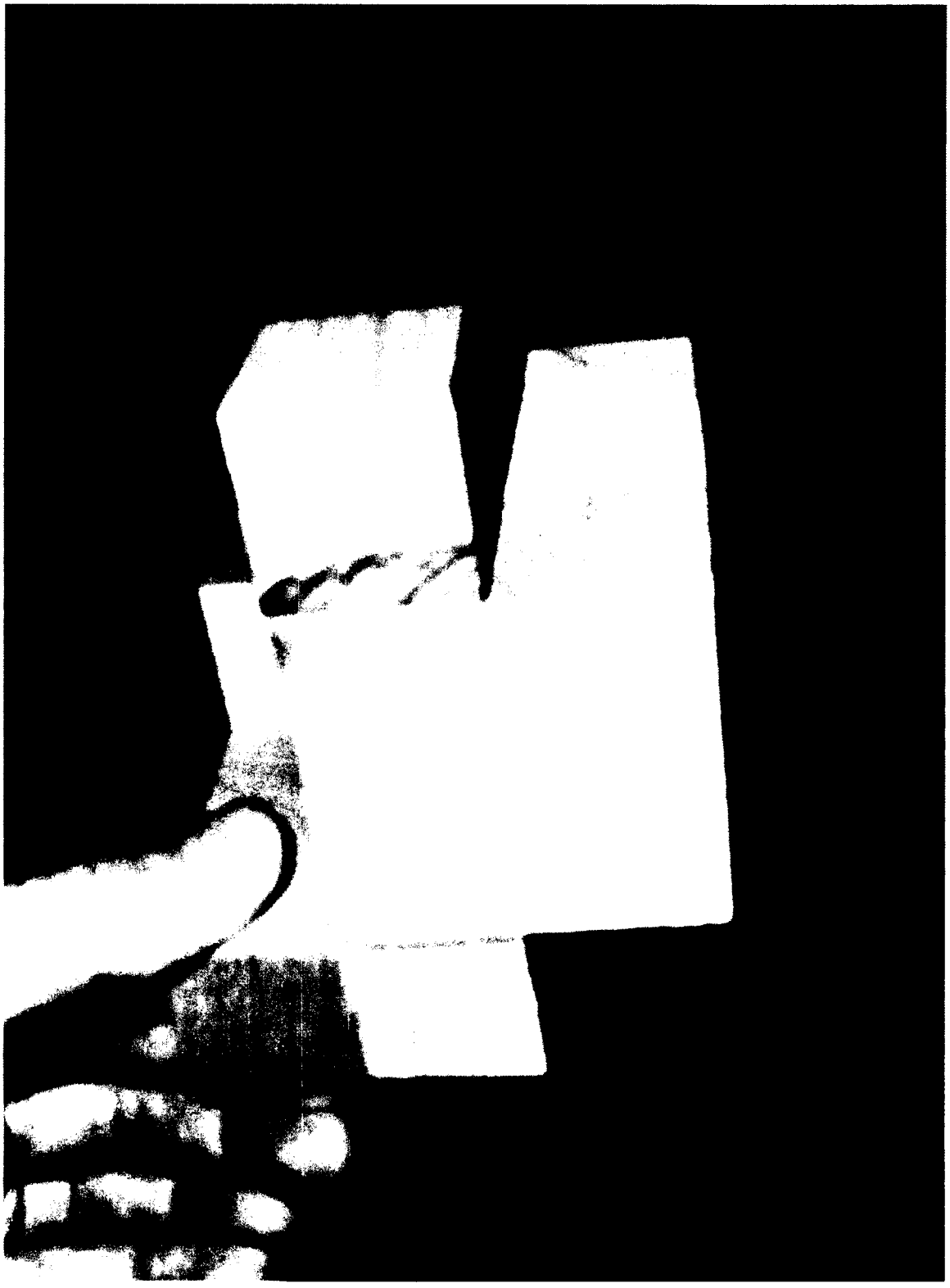

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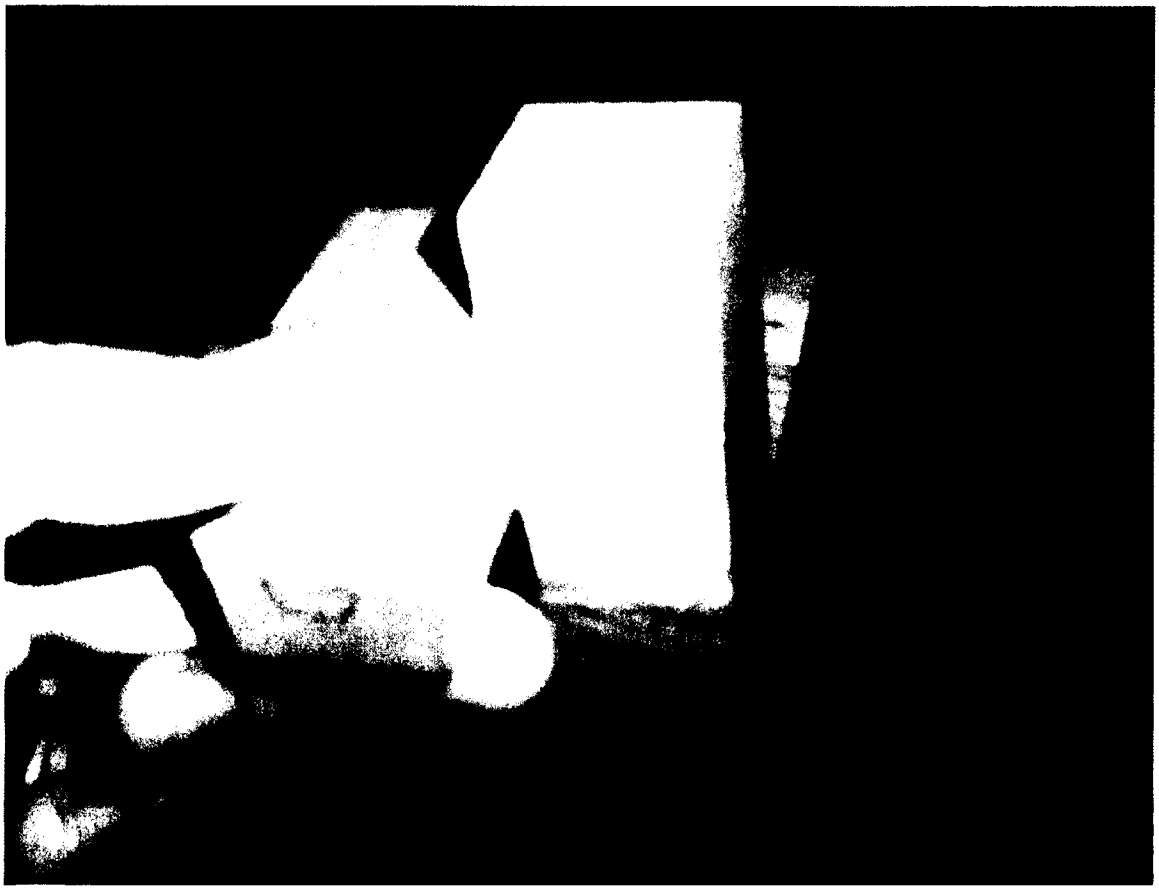

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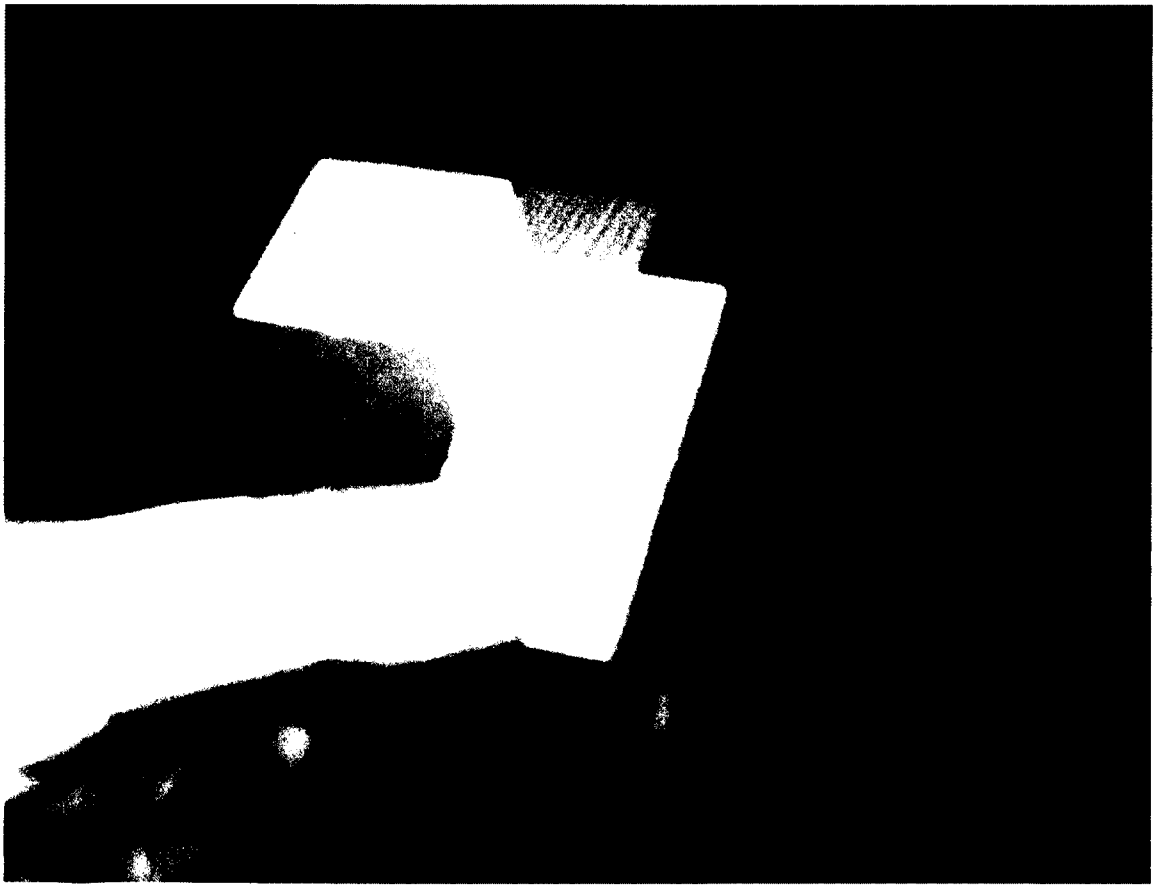

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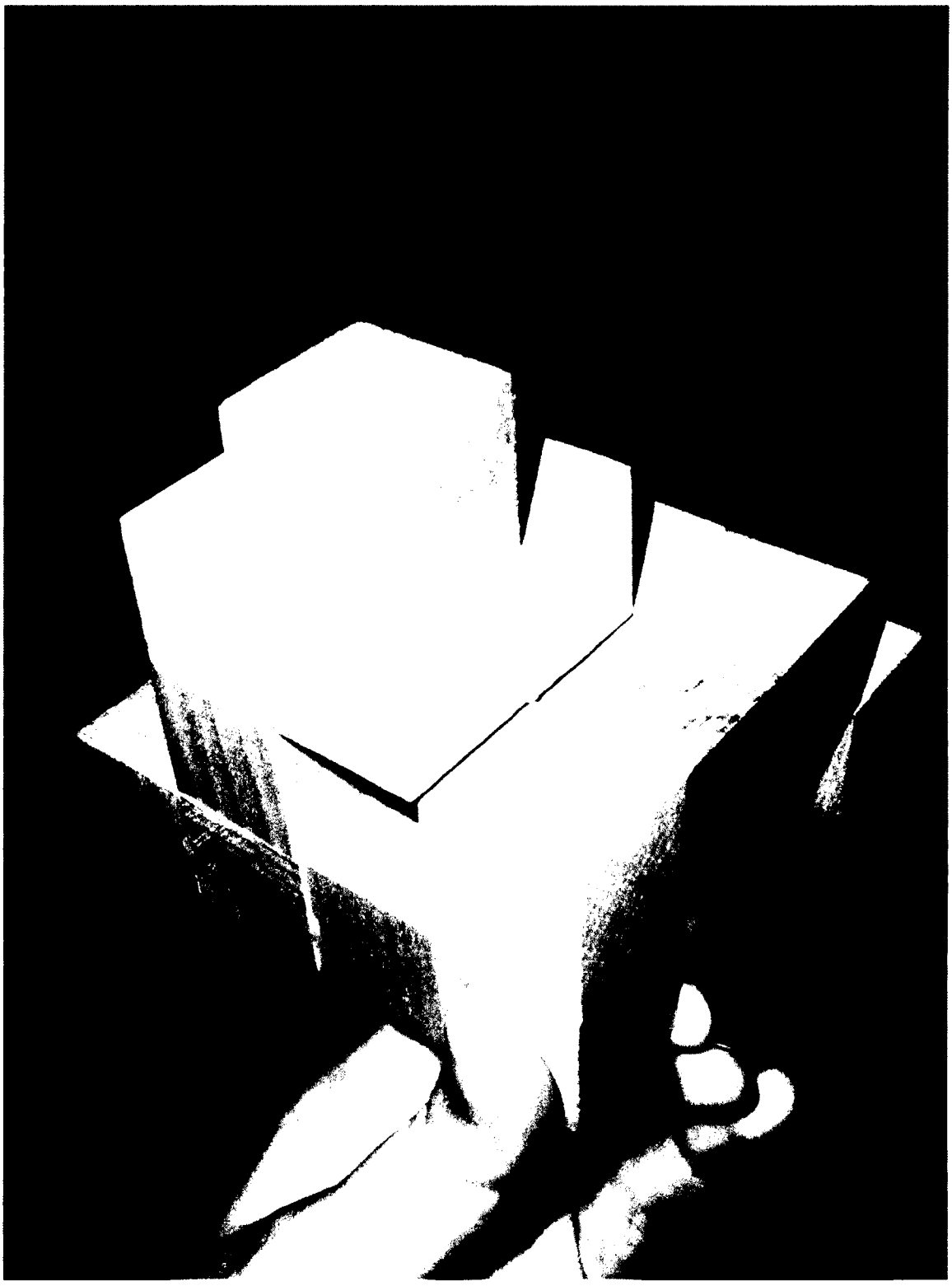

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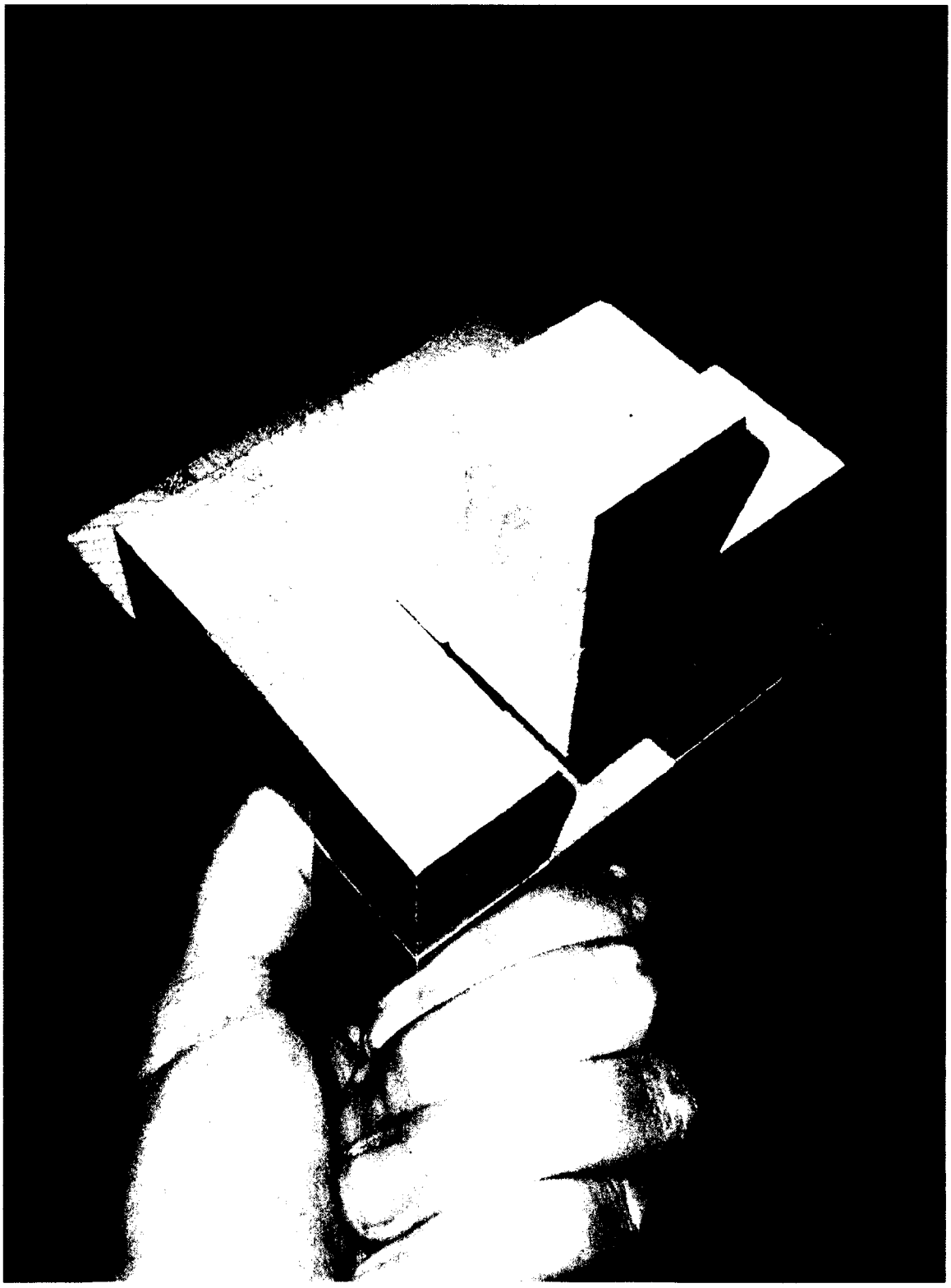
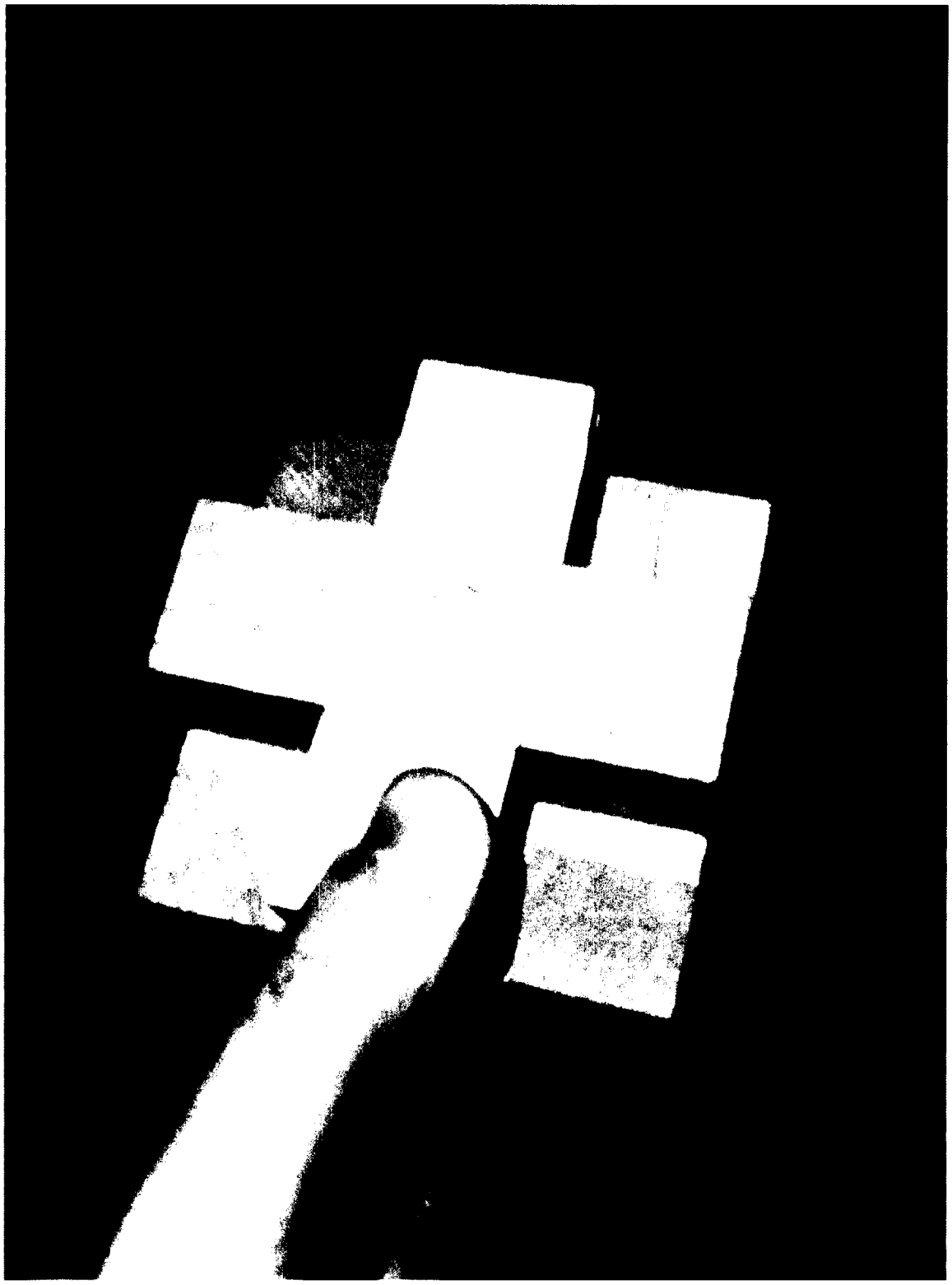


Tactile Block Configurations

Tactile Block Configurations

Tactile Block Configurations

Tactile Block Configurations



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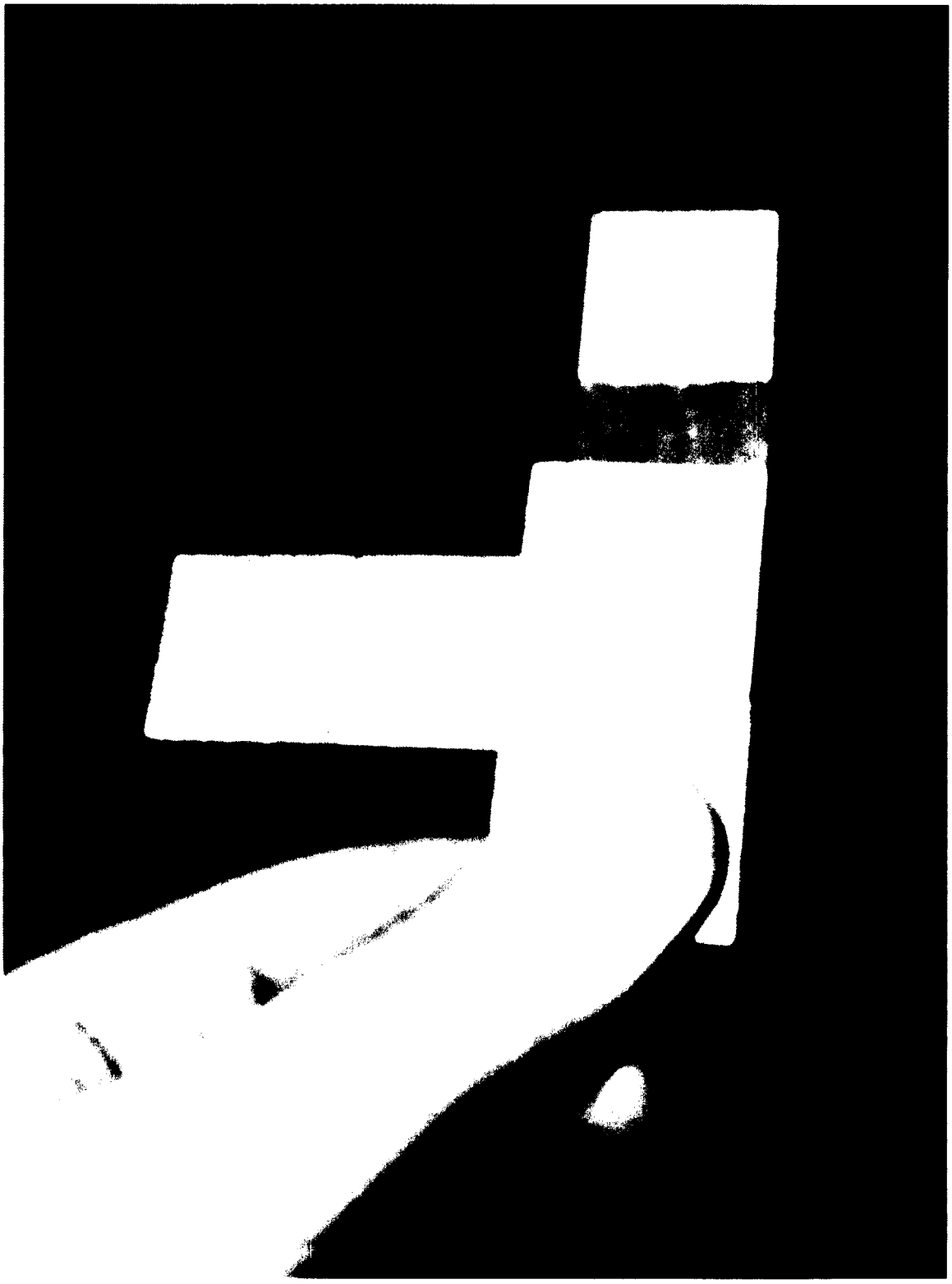
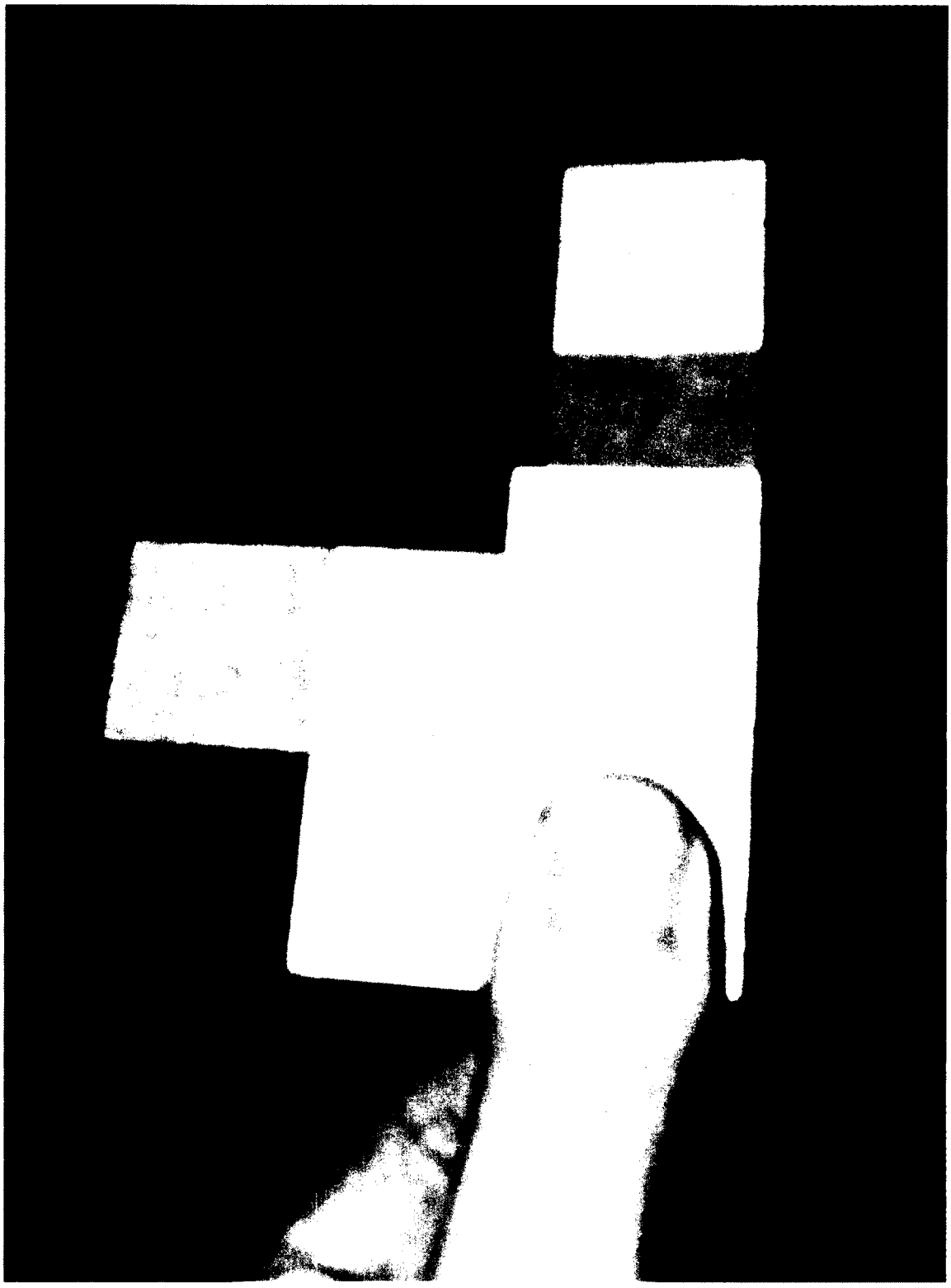
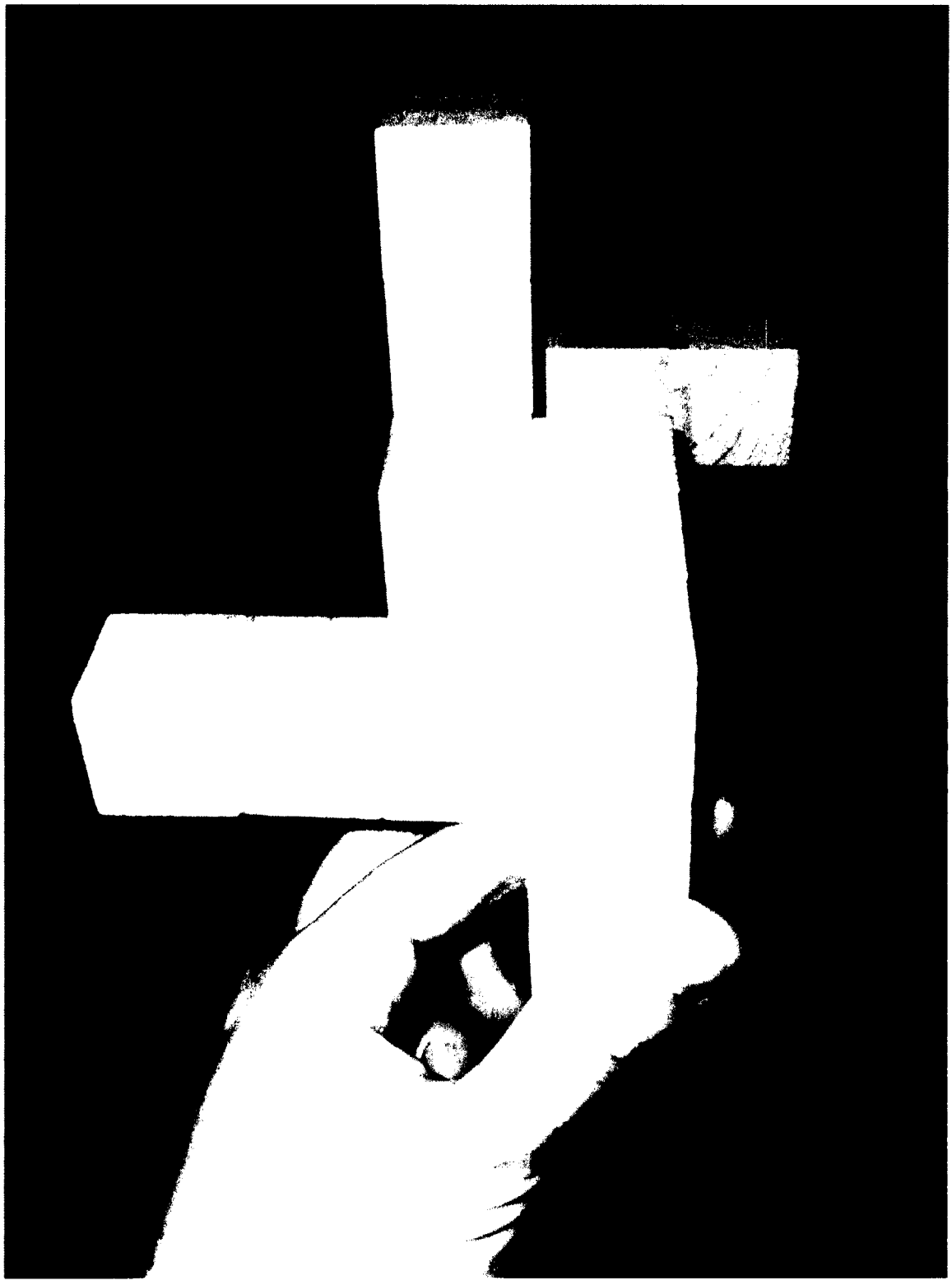


Tactile Block Configurations



Tactile Block Configurations

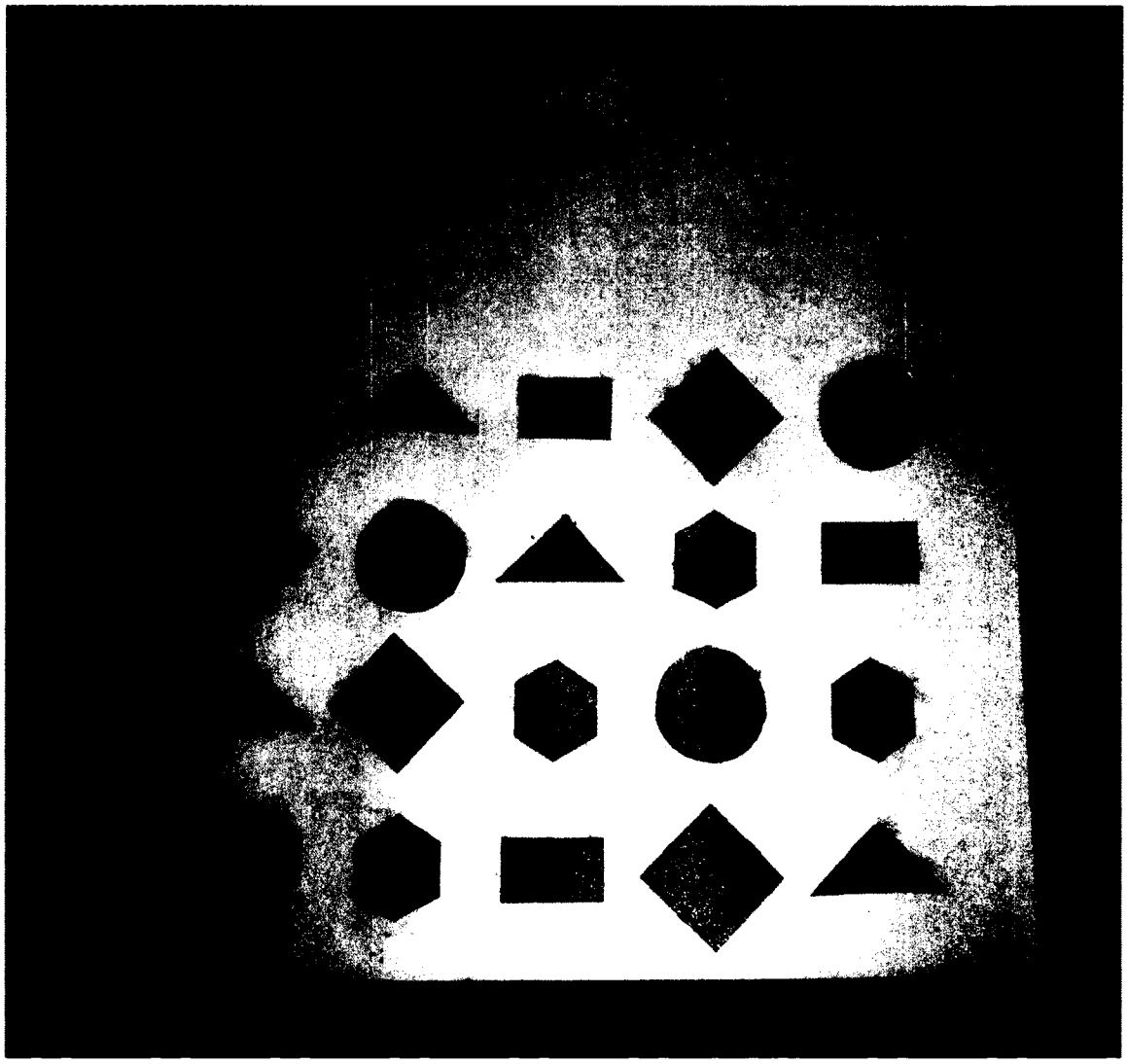
Tactile Block Configurations



Tactile Block Configurations

APPENDIX E

TACTILE MATCHING



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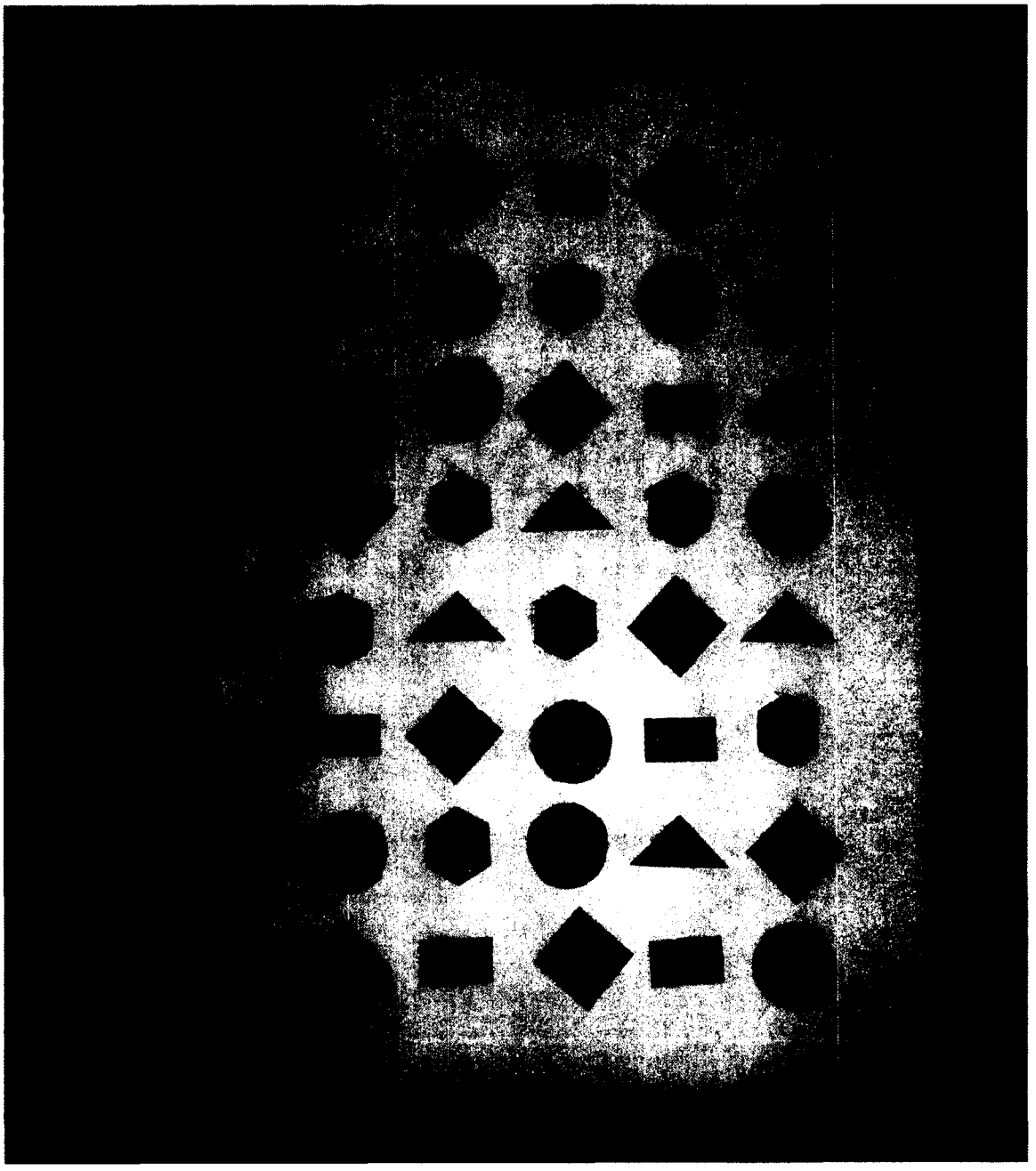

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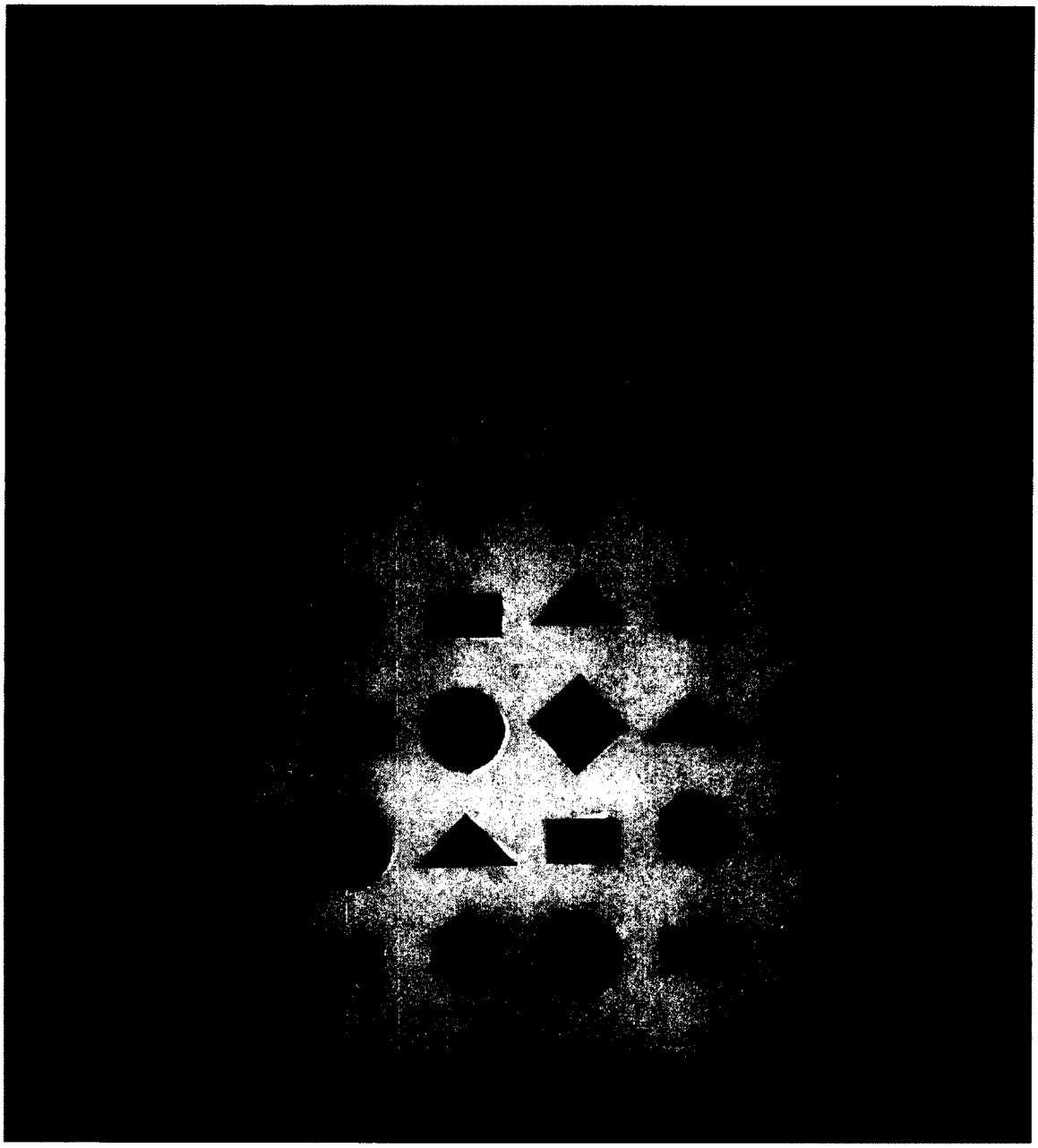

Tactile Matching

APPENDIX F

HUMAN USE APPROVAL LETTER

LOUISIANA TECH
UNIVERSITY

MEMORANDUM

OFFICE OF UNIVERSITY RESEARCH

TO: Mr. Richard Sylvester, Dr. Tony Young and Dr. Edward Bell

FROM: Barbara Talbot, University Research

SUBJECT: HUMAN USE COMMITTEE REVIEW

DATE: January 11, 2012

In order to facilitate your project, an EXPEDITED REVIEW has been done for your proposed study entitled:

"Intellectual Assessment of Individuals Who Are Blind"

HUC 914

The proposed study's revised procedures were found to provide reasonable and adequate safeguards against possible risks involving human subjects. The information to be collected may be personal in nature or implication. Therefore, diligent care needs to be taken to protect the privacy of the participants and to assure that the data are kept confidential. Informed consent is a critical part of the research process. The subjects must be informed that their participation is voluntary. It is important that consent materials be presented in a language understandable to every participant. If you have participants in your study whose first language is not English, be sure that informed consent materials are adequately explained or translated. Since your reviewed project appears to do no damage to the participants, the Human Use Committee grants approval of the involvement of human subjects as outlined.

Projects should be renewed annually. ***This approval was finalized on January 11, 2012 and this project will need to receive a continuation review by the IRB if the project, including data analysis, continues beyond January 11, 2013.*** Any discrepancies in procedure or changes that have been made including approved changes should be noted in the review application. Projects involving NIH funds require annual education training to be documented. For more information regarding this, contact the Office of University Research.

You are requested to maintain written records of your procedures, data collected, and subjects involved. These records will need to be available upon request during the conduct of the study and retained by the university for three years after the conclusion of the study. If changes occur in recruiting of subjects, informed consent process or in your research protocol, or if unanticipated problems should arise it is the Researchers responsibility to notify the Office of Research or IRB in writing. The project should be discontinued until modifications can be reviewed and approved.

If you have any questions, please contact Dr. Mary Livingston at 257-4315.

LOUISIANA TECH
UNIVERSITY

MEMORANDUM

OFFICE OF UNIVERSITY RESEARCH

TO: Mr. Richard Sylvester, Dr. Tony Young and Dr. Edward Bell

FROM: Barbara Talbot, University Research

SUBJECT: HUMAN USE COMMITTEE REVIEW

DATE: January 11, 2012

In order to facilitate your project, an EXPEDITED REVIEW has been done for your proposed study entitled:

"Investigating the Validity of the Tactile Assessment of Performance"

HUC 916

The proposed study's revised procedures were found to provide reasonable and adequate safeguards against possible risks involving human subjects. The information to be collected may be personal in nature or implication. Therefore, diligent care needs to be taken to protect the privacy of the participants and to assure that the data are kept confidential. Informed consent is a critical part of the research process. The subjects must be informed that their participation is voluntary. It is important that consent materials be presented in a language understandable to every participant. If you have participants in your study whose first language is not English, be sure that informed consent materials are adequately explained or translated. Since your reviewed project appears to do no damage to the participants, the Human Use Committee grants approval of the involvement of human subjects as outlined.

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If you have any questions, please contact Dr. Mary Livingston at 257-4315.