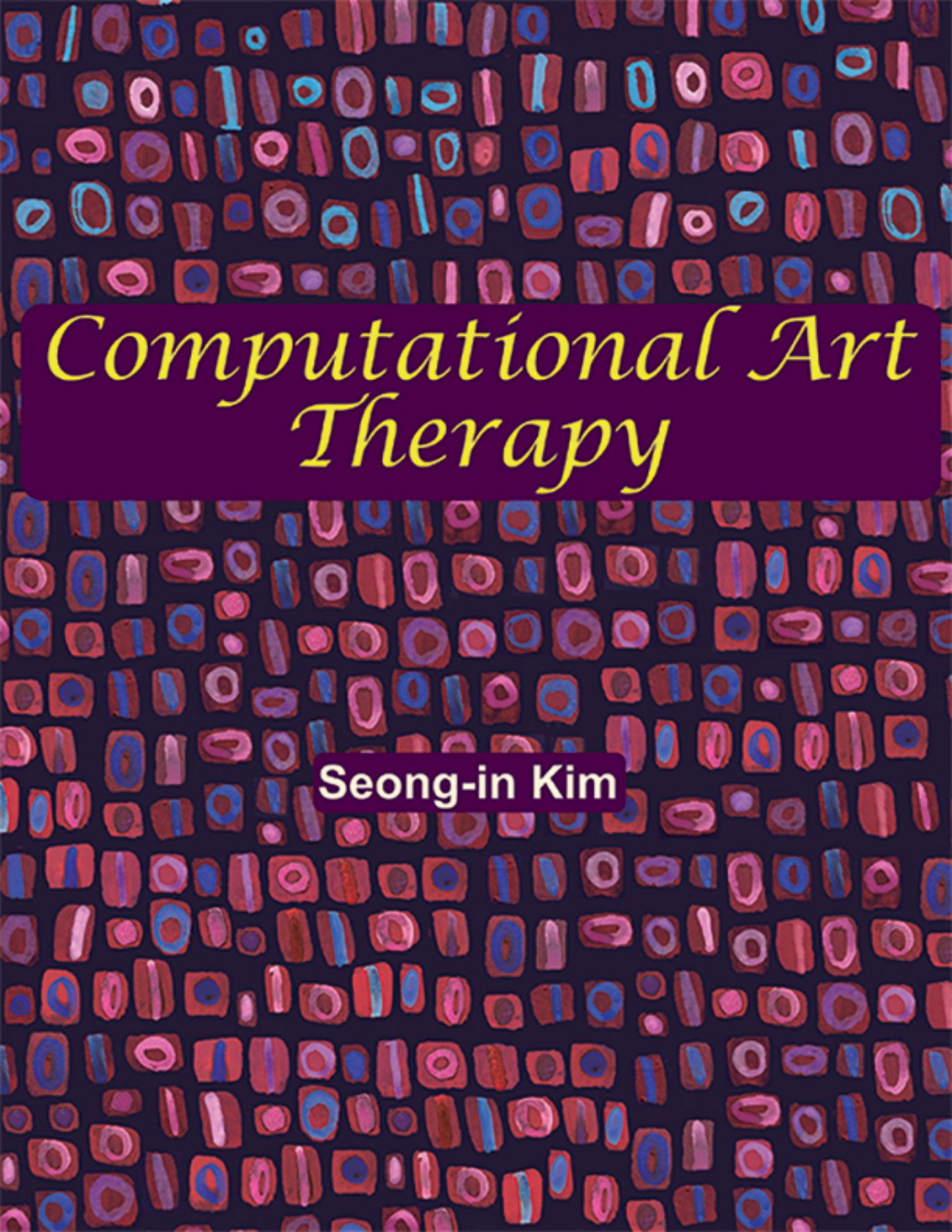
Computational Art Therapy
Seong-in Kim

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By

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To

my parents who were ever so proud of me,
Honorable Yun-Haeng Kim,
Justice of the Supreme Court of Korea,
Eung-Kyu Jung,

and

my wife who loves me so much,
Myeong-hee.

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Seong-in Kim, professor of Industrial Engineering, at Korea University since 1979. He received his B.S. degrees in Economics (1970) and Applied Mathematics (1973) from Seoul National University, and his M.S. (1975) and Ph.D. (1979) in Industrial Engineering from the Korea Advanced Institute of Science and Technology (KAIST). He was a post-doctoral researcher (1981-1982) at Virginia Polytechnic Institute and State University in Blacksburg, Virginia. He served as the Dean of Academic Affairs, the Dean of Admissions Office, and the Director of Computing and Information Center at Korea University. He was Outside Director of Young-Poong Co. and President of the Korean Institute of Industrial Engineers (KIIE).

He has produced 17 PhDs and 77 MAs. His research interests include applied statistics, artificial intelligence, and quality control. He developed a computer sentencing system in criminal cases, and recently he has focused on developing computer systems in art therapy. He is the author of several books on statistics and statistical quality control, *Statistical Inference on Bernoulli Trials*, DaeWoo Series, 1995, *Statistical Quality Control*, Park-young-sa, 1990, and *Quality Control in Service Industry*, Chong-moon-gak, 1995. His articles have appeared in journals including *Technometrics*, *Communications in Statistics*, *Journal of Quality Technology*, *Statistics and Probability Letter*, *Transportation Science*, *Operations Research Letters*, *Computer and Operations Research*, *Naval Research Logistics*, *Discrete Applied Mathematics*, *Expert Systems with Applications*, *Photonic Network*

Communications, *Telecommunication Systems*, *Networks*, *Industrial Engineering Transactions*, *Global Optimization in Engineering Design*, *Industrial Engineering*, *Rutgers Journal of Computers and Law*, *The Arts in Psychotherapy*, *Expert Systems Research Trends, Hydrometallurgy*, *Metallurgical and Materials Transactions B*, *Art Therapy: Journal of American Art Therapy Association*, and *New Ideas in Psychology.* He wrote two book chapters in *Expert systems research trends* and *The Wiley handbook of art therapy*.

He holds 14 patents on computer sentencing and computational art therapy registered in Korea, Japan, and the U.S.A. He has published several newspaper articles on criticizing the current Korean college entrance system including articles in Joong-ang-il-bo (9, July, 2005), Dong-a-il-bo (25, November, 2000), Cho-sun-il-bo (14, November, 1998), etc.

He is the recipient of the Best Paper Award from KIIE (1996), the Award for Excellent Paper in Science and Technology from the Korean Federation of Science and Technology Societies (1992), and the Best Research Award from the Korean Art Therapy Association (2007). He developed commercial software packages such as Statistical Process Control and Acceptance Sampling, which have been integrated as modules of Samsung's UniERP.

His laboratory, the AAALab (Artificial intelligence, Applied statistics, and Art therapy Lab), conducts research on interdisciplinary studies incorporating various fields such as computer science, law, statistics, art therapy, etc. Currently he heads Kims_CATS_COMS, a corporation that has developed the Computer Art Therapy apps as well as Computer Sentencing System web.

Acknowledgments

My training and experience in interdisciplinary subjects - economics, mathematics, and engineering - are what paved the way for me to write this book. It all began with the support and encouragement from my late parents. In the early 1970s, my father, who was then a Justice of the Supreme Court of South Korea, and I together developed a model for computer-aided sentencing guidelines, which awaits to be further developed. I had defied his wish for me to follow in his footsteps in the field of law but it was not all lost. His wish skipped a generation: my younger son entered the legal field and as if by fate, my older son became a professor in artificial intelligence. My greatest wish for my two sons, whom I am deeply proud of and love very much, is that they together improve another area of interdisciplinary work, the computerized sentencing system on criminal cases which their father and grandfather had developed. It will be the most honorable project, linking three generations, that belatedly fulfills their grandfather's wish that their father fell short of.

Soon after I started working on this book, I had to battle cancer, which is now in remission. My wife, Myeonghee, stood beside me as she had done for the past 44 years. This book would not have been possible without her. Thank you and I love you more than all the wine and dogs in the universe.

Michael Payne Thomas, the president of my publisher, Charles C Thomas Publisher, allowed me many extensions in the past six years with continuous encouragement and sincere wishes for my speedy recovery. Thank you again, and although this specific topic text might not be widely popular among various readers, I hope this book can become a bestseller in the field of art therapy for opening a new horizon of emerging academic areas. To Youngho Lee, his continuous push for me to finish the book is what kept me going in the final chapters. Without his inspiring this book would still be in drafts, collecting dust. Seok Yoo's occasional progress in developing app and web systems for art therapy and computer sentencing replenished my energy when I was in lack of it.

Wae Sun Choi, formal president of Korean Arts Therapy Association, and Rubin Cruz, editor of *The Arts in Psychotherapy*, gave me the opportunity to venture into the world of art therapy. They encouraged me along the way and published my research papers overriding the resistance from the pessimists. I still cannot forget the thrill I felt when I presented this new concept of Computational Art Therapy (CAT) at conferences in the U.S.A. as well as in Korea. Linda Gantt and Donna Betts came to every presentation of mine at many conferences with strong encouragement. It was a great pleasure that, together with Sarah Deaver, the four of us co-authored and presented our common research interests. Cathy Malchiodi, among many art therapists, showed great interest and anticipated further development of the CAT. All the attention they gave to my work almost made me think of myself as a burgeoning art therapist. Subsequently, constructive critiques and invaluable suggestions from Lynn Kapitan, editor of *Art Therapy: Journal of American Art Therapy Association*, and Dave Gussak, editor of *The Wiley Handbook of Art Therapy*, on my manuscripts gave me a sort of reality check, reminding me that I am an engineer interested in the CAT; after all, I am only a novice in the field of art therapy.

This book is based on many published research papers. Hyung-Seok Kang, Ji-Ho Ghil, and Jong-Hoon Kim, the three musketeers, continued to work with me beyond my retirement from Korea University, participating in computerized analysis as well as software development. Especially, Jong-Hoon, the last doctorate under my guidance and my companion of kimscatscoms (Kim's Computational Art Therapy System and COMputer Sentencing) co., has given his all in the whole process of books, design, illustrations, tables and even making InDesign files, and now he is thinking about extending the company to kimscatscomspubs (PUBlication System). Also, I thank his fiancée, So-Hwa Son, for the beautiful cover. Hyuk Kwon, a winner of world hackers' competition, finally wrapped up the software package. Jun Bae, Youn-Hee Kim, Youn-Joo Oh, Jeonghee Han, Eun-joo Hong, Hyun Kyung Kim, and Eun-Jin Kim are the co-authors of some of the published research papers included in this book.

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Lastly, I must thank my most faithful writing companions, wine and Julie. Wine may be the biggest contributor to my illness, and without it this book just might have been completed a few years earlier. My dog Julie, who came to me after my illness as sort of a reward for surviving cancer, has kept me company and entertained me during countless hours of writing and proofreading at my new research lab, a tree house-like-space where you can

always expect the company of good wine and an animal friend. This space is aptly named WA-GAE-YEON, WA for *wa-in* (wine in Korean), GAE for *gae* (dog in Korean), YEON for *yeon-gu-shil* (lab in Korean). I guarantee it is the best hide out to drink and write with my dog and you are invited anytime for beer or wine, or both.

I thank all of you, and countless others, from the bottom of my heart. I am just grateful to complete this long term project which took unexpected 7 years, during which I even doubted that I would finish.

Preface

Art therapy and computer science

The invaluableness of art as a media for expressing oneself is well conveyed in the widely quoted words of Georgia O'Keefe (1887-1986), "I found that I could say things with colors and shapes that I couldn't any other way - Things I had no words for" (Tripp, 2016). As an engineer and an art therapy researcher, I believe that an interdisciplinary approach incorporating computer science with art therapy using art as a media can significantly expand the potential and value of art therapy. Lord Kelvin (1824-1907) pointedly stated: "When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science" (Thomson, 1889). Art therapy, accompanied by scientific thought, can achieve its greatest effect in its purpose of improving and enhancing the physical, mental, and emotional well-being of individuals of all ages.

The purpose of this book is to explain, in a reader-friendly format, the ways in which computer technologies can help art therapists improve the quality of their practice and advance the theory of art therapy. Computer science research, especially in the field of artificial intelligence, has developed methods for computers even to think, learn, and improve by themselves. Of course, art therapists already use computer technologies for various purposes, such as word processing, business-related packages, computer graphics, digital storage, retrieval of client artwork, e-mail, website, etc. An interdisciplinary approach to art therapy can critically benefit from artificial intelligence, however, the purpose of which is to make a computer that can imitate intellectual actions of human beings.

Ill-structured paradigm

Knowledge in art therapy is largely empirical, heuristic, and subjective, based on an art therapist's individual professional expertise and experience, which are not always amenable to organized algorithms. Thus, the field of

art therapy can be classified as a so-called "ill-structured paradigm," which is referred to in the field of artificial intelligence as a vague and unclear problem domain in which there are few means for finding a solution and in certain cases the solutions found are inevitably contradictory. This nature of art therapy makes decision-making in art evaluation and art interpretation complex and difficult for art therapists. In this sense, art therapy is analogous to such areas as economic demand forecasting, weather forecasting, diagnosis of diseases, or judicial sentencing. The use of artificial intelligence in these areas is already in progress and has yielded significant results. In the search for a solution to the problem dealing with the subjective, ambiguous, inconsistent, and sometimes contradictory nature of the huge volume of knowledge involved, art therapists should be made aware of new computer technologies applicable to the improvement of practice and theory in their field. In this era of rapidly expanding computer technologies, discourses of art therapists with computer technologies could be made livelier and more productive, creating new perspectives on which to build knowledge.

Interdisciplinary study

This book is concerned with the interdisciplinary studies applying computer technologies to the theory and practice of art therapy. The contents consist of the author's sixteen papers published, twelve patents in Korea, Japan, and the U.S.A., and other relevant materials, all organized in a logical sequence. This book is intended for art therapy courses at upper undergraduate and graduate levels. No prior computer knowledge is assumed. The difficult concept of computer science is explained in a simple and concrete way with illustrations, sample drawings, and case studies. This book explains statistical methods, various functions of a computer, technologies in digital image processing, computer algorithms, methodologies in expert systems, and the Bayesian network. All these elements can be used to improve the practice and theory in the evaluation of art and the interpretation of art. The readers do not need to worry about unfamiliar terms such as digital image, algorithm, expert system, and Bayesian network which appear here. Neither should they be concerned about pixel, cluster, edge, blurring, convex hull, regression, etc., the terms which appear later in the book. These terms will be explained with illustrations and drawings for easy understanding.

Art therapists are often asked by parents to diagnose their child's psychological state by evaluating and interpreting a drawing created by the child. Identifying a person's state of mind by evaluating only what they have drawn is just a small part of art therapy. Unfortunately, this small part is all what this book is about. Interpretation of drawings on drawer's psychological state based on the results of elements evaluation, however, is more than just a small part of art therapy and remains one of the most important and fundamental tasks for art therapists to perform. Performing that task no longer needs to be done manually by the therapists themselves because, as this book argues, computerized systems can perform the steps of evaluation

and interpretation. The author strongly believes that the proposed computer systems will contribute to the advancement of art therapy.

Organization of the book

As the title, Computational Art Therapy (CAT), indicates, this book is a study of art therapy using computer technologies. Part One, Art Evaluation, is concerned with the computerized art evaluation of elements of drawings, and Part Two, Art Interpretation, is concerned with the computerized art interpretation of the drawer's psychological state. Before the two parts, in the Prologue, definitions, the need for, potential contributions, and the pros and cons of CAT are introduced. The Prologue introduces common material integral to two parts, including the Computer Color-Related Elements Art Therapy Evaluation System (C_CREATES) which is a computerized system for the evaluation of elements of a drawing. Each chapter begins with an "abstract," "summary," "keynote," or "key point(s)" section or a combination of any two of these which is appropriate for the chapter. When readers come across unfamiliar materials or contents, they don't need to fear. Rather, the reader is encouraged to imagine freely. Whether the imagination is correct or not will become clear as the reader progresses through the chapters and to the CAT.

The first two chapters in Part One develop methods for the evaluation of 12 basic elements in the C_CREATES. These elements are basic in the sense that the evaluation results are perfectly accurate, thus their validation is not necessary. The next 5 chapters develop methods for the evaluation of 7 elements, which are applied ones in the sense that the evaluations are based on the basic elements. The evaluation results are consistent but can be somewhat variable even if the computerized methods are applied, and thus the reliability of human raters and the validity of the system need to be proved. The last chapter applies the various evaluation methods to an art therapy tool and demonstrates how the evaluation results of Part One can be used for the interpretation of Part Two.

The first four chapters in Part Two deal with the expert systems for the interpretation of a drawing. The chapters cover, respectively, the concept, the reasoning process, and two applications to art therapy tools. The following three chapters develop systems for, respectively, the decision on whether a drawing is made by a patient or a non-patient, the estimation of the level of a psychological state, and the comparison of the efficiencies of various tools in estimating the level of the psychological state. The last chapter proposes the probabilistic interpretation instead of traditional deterministic one. See the prologue for a more detailed flow among the chapters.

The epilogue discusses the contributions of the CAT and suggests its potential for further developments. Although this book is self-contained, CD or companion website, http://www.ccthomas.com/cat is available to provide readers with software packages of the C_CREATES with program files, original drawings, samples, etc., which art therapy practitioners can

easily use via their PC to access technologies to help them obtain a more reliable analysis. Practitioners can thus save time and effort in their practice, easily enhancing the quality of their practice. The manual of the software package is given in the Appendix.

Author's hope The author hopes this book will not only promote the use of various art therapy tools but also provide a foundation for new methodologies through which art therapy researchers can develop their own methodologies to improve the practice and theory of art therapy. The author wishes that interdisciplinary studies incorporating art therapy, psychology, psychiatry, art, computer science, applied statistics, etc. will be performed under the umbrella of the CAT.

Finally, I admit, as an engineer, that my interest in the CAT lies mainly on the technical side. I am, after all, a novice in art therapy. I acknowledge there remains a significant amount of further study. It is my hope that any oversights and errors found in this work will serve as a stepping stone for the betterment of future CAT.

Seong-in Kim

Contents

PART ONE
ART EVALUATION

Introduction to the Computational Art Therapy (CAT)

Prologue

Keynote

In this section, we introduce the main theme of the book. We define the Computational Art Therapy (CAT) as an art therapy that actively uses various computer technologies including quantitative statistical methods. The CAT is proposed as an approach to solve the "Ill-Structured Paradigm (ISP)" problems in the field of art therapy.

The art evaluation of Part One and the art interpretation of Part Two in this book demonstrate the difference in methodology between the CAT and conventional art therapy, by focusing on the computerized evaluation of elements of drawings using the Computer Color-Related Elements Art Therapy Evaluation System (C_CREATES) (Kim, Bae, & Lee, 2007; Kim, 2010) and the computerized interpretation of a drawing regarding the psychological state of the creator of the drawing. We describe the fundamental computer technologies and methods commonly used in the following 16 chapters of this book. In addition, we summarize the flow and the organization of the chapters.

The primary goal of the CAT is to provide objective and quantitative evaluation of elements and systematic interpretation of art, computerize art therapy tools, develop new methodologies for the improvement of practice and theory, and thus establish art therapy as a science.

P.1 The need of computer technologies in the field of art therapy

P.1.1 *Present status of computer technologies in art therapy*

Art therapists are proud of using art in their profession. The invaluableness of art as a medium for expressing oneself is well conveyed in the famous quote of Georgia O'Keefe (Tripp, 2016), "I found that I could say things with colors and shapes that I couldn't any other way - Things I had no words for." However, people and art are so complex (Cohen & Mills, 1994) that scientific analysis of such subjects is seemingly impossible. This book aims

to help change this conventional belief. In relation to art evaluation and art interpretation, this Prologue delineates the strength and weakness as well as the potential of using computer technology in art therapy.

Since the advent of mankind's first computer in 1946, computer technology has made remarkable progress and greatly influenced human society. There are numerous fields which employ computer technology, such as the Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), and Computer Aided Education (CAE). Various fields including manufacturing, design, education, and law have progressed remarkably by adopting rapidly changing computer technologies. In medicine, an expert system of artificial intelligence, MYCIN, developed in 1972 to diagnose epidemic diseases and prescribe anti-biotics, has had a tremendous effect (Shortliffe, 1972). IBM's Watson, a super computer powered with artificial intelligence, is changing health care, from diagnosing disease to treating it (Smith, 2015) - correctly diagnosing a patient within minutes, something doctors failed to do after months (Billington, 2016).

P.1.2 *Problems and difficulties in art therapy*

Compared with other fields, art therapy has been relatively slow in adopting computer technology. Art therapists of course have been using PCs and e-mails every day, and have tried remote sessions on line to improve the quality of art therapy practices (Peterson, Stovall, Elkins, & Parker-Bell, 2005; McNiff, 1999; Parker-Bell, 1999; Malchiodi, 2000; Betts, 2006; Hartwich & Brandecker, 1997; Orr, 2006a). Thong (2007) combined traditional art therapy tools such as drawings, pictures, and collages with computer software of Photoshop (Adobe Creative Team, 2004) and Flying Colors (de Jong, 1993). Im, Oh, Lee, Chang, and Park (2010) developed a computer module that provides a familiar drawing board so that the client can easily sketch and draw online and the art therapist can review the whole sketching process in a time-efficient manner. On the other hand, Belkofer (2011) discussed the ethics in the context of using participatory social media such as Facebook, YouTube, Twitter, Skype, Blogging, and online video games, as well as e-mail for art therapy sessions. However, most of art therapy research so far has been confined to using the computer as a tool for art making (McLeod, 1999), and as a medium for distance art therapy of remote sessions with clients (Malchiodi, 1999).

Several studies have gone beyond the above practice, using a computer system for evaluating drawings (Kim, Bae, & Lee, 2007; Kim, 2008a; Kim, Kang, & Kim, 2008; Kim, Han, & Oh, 2012; Kim, 2010; Mattson, 2009, 2011, 2012a, 2012b) and interpreting drawings (Kim, Ryu, Hwang, & Kim, 2006; Kim, Kim, Lee, Lee, & Yoo, 2006; Kim, Kim, & Kim, 2008; Kim, Han, Kim, & Oh, 2011). This line of research is still scarce, however. One of the reasons for this limited state of research is the lack of art therapists' knowledge about state-of-the-art computer technology. Some practicing art

therapists were initially skeptical about the effectiveness of technological tools (Fryrear & Corbit, 1992; Hartwich & Brandecker, 1997), just like in other fields that depend on human expertise and skill. Asawa (2009) reported that most art therapists' responses to technology were anxiety and fear.

It should be stressed here that the main purpose of using computers is not to replace human experts but rather to aid them by providing relevant information, reducing the time and effort in their work, and providing convenience (Kim, Kang, & Kim, 2008). It is now generally recognized in the art therapy field that computer technology should be actively understood and leveraged. We note this trend from a number of developments: In 1999, the American Art Therapy Association (AATA) published a special journal issue on "Digital Art Therapy." In 2001, the title of the Psychotherapy Networker journal was "Our Technology Ourselves: How Digital Revolution is Changing Psychotherapy." In 2007, Kapitan (2007) emphasized the use of computers for managing and practicing art therapy, and stressed the importance of multi-disciplinary research for new media. In 2008, the AATA conference held in Cleveland, US, featured the theme, "Art Therapy on the Cutting Edge: Invention and Innovation." In 2009, the AATA published a special journal issue on "Art Therapy's Response to Techno-Digital Culture."

Another reason for the slow adoption of computer technology in the field is that knowledge in art therapy is mostly empirical, heuristic, subjective, inconsistent, and even contradictory, relying on the art therapist's professional expertise and experience. The field of art therapy could be classified as a so-called "Ill-Structured Paradigm (ISP)," the terminology often used in expert systems, which refers to a vague and unclear problem domain in which well-defined algorithms or an objective means for finding a solution hardly exist. In certain cases the solutions found are inevitably contradictory (Giarratano & Riley, 2005). The nature of art therapy itself makes the decision-making complex and difficult for art therapists. In this sense, art therapy is analogous to areas such as economic demand forecasting (Chang, Wang, & Liu, 2007), weather forecasting, diagnosis of diseases (Shortliffe, 1972), or judicial sentencing in criminal cases (Kim, Kim, Lee, Kim, & Baik, 1992). Gussak and Nyce (1999) pointed out that art therapy is eclectic in theory and practice and not reducible to a single set of algorithms.

P.1.3 *Computer technologies as a solution*

Solving problems with computers require scientific methods based on quantification. Since it is seemingly difficult, if not impossible, to quantify the process of art therapy, the field has not paid enough attention to using computers to its fullest extent. It has also been widely believed in the field that the ability to reason qualitatively, which is essential in art therapy, cannot be specified as a computer program. However, art therapists should now break out of this conservative view. Lord Kelvin, early on in history, emphasized

the importance of quantification, stating that "measuring whatever it is and expressing it in numbers may be the beginning of knowledge advanced to the stage of science (Thomson, 1889)." Many art therapists still claim that their evaluation of elements of drawings and interpretation regarding drawers' psychological state are complex and not amenable for quantification. However, computer algorithms such as color analysis and edge extraction can provide basic building blocks for objectification and quantification of art evaluation.

Furthermore, recent progress in artificial intelligence research allows computers to solve problems where objectification and quantification are difficult or even impossible. Artificial intelligence enables computers to reason with expert knowledge like humans. In the past, we used computers only for problems that were obviously quantifiable so as to write a sequence of instructions (i.e. an algorithm) to solve them. However, we can now make computers use human expert's knowledge and experience to solve problems with uncertain or imperfect specifications. Kim (2008b) claimed that art therapists should embrace the techniques in artificial intelligence to assist art evaluation and art interpretation. Art therapy, supported by state-of-the-art computer technology, can make significant contribution to improving the physical, mental, and emotional well-being of individuals of all ages, which is ultimate goal of art therapy.

P.1.4 *The definition of Computational Art Therapy* (*CAT*)

In this book, we define the Computational Art Therapy (CAT) as an art therapy that actively utilizes various computer technologies including quantitative statistical methods. This is different from the limited use of computers as a tool for generating drawings or communication media for remote sessions. Furthermore, it applies computer technology such as artificial intelligence to evaluate and interpret drawings.

P.2 Computer technologies relevant to art therapy

P.2.1 *Built-in functions of a computer*

First generation computers were able to process 10^2 instructions per second. Current PCs can process 10^{12} instructions per second. The ability to process a huge number of instructions per second makes software faster, saving art therapists' time and effort in many aspects. The first generation computers were able to store several thousand characters, compared with more than 10^{12} characters nowadays. The ability to store a huge amount of information allows art therapists not only to store the drawings from clients as well as video recording of the art drawing process and evaluation results, but also to retrieve them any time. Today, the size of the population with access to the internet is estimated to be bigger than one billion. The progress in