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Approaches to Teaching ECG Interpretation and a possible

"Drawing on the Right Side of the Brain" novel approach that may accelerate reading of ECG's, which may increase observational acuity, improve diagnostic accuracy and speed, *and* may have more application than just ECG interpretation benefits

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Introduction

Though the literature is hardly scant, it is not endless. There are multiple approaches to teaching ECG interpretation and gaining expertise. After looking over about twenty general approaches to teaching ECG's, none of which seem to produce wildly favorable nor overly efficient results, I've had my eyes opened to aspects of teaching ECGs I've known nothing about. Things like the general category of "**pedagogy**": those things observers and professors of education have found that works. This is new to me – and a later arrival in the writing this paper.

There's been an explosion of **on-line teaching** and applications of technology - but not nearly as many tests to see if these work. There are sub-specialists who maintain ECG interpretation should be **left to the specialists** – but of course they can't (in any universe) be present for *every* ECG reading – especially in emergency situations.

There are those **sub-specialists** who argue it will only be a matter of time before computer ECG **software** will have the power to do all the interpreting by itself – but that day is a long ways off (if ever). So in the meantime we must make do. But "making do" by all accounts just isn't "cutting it". So we're left with the situation where many clinicians will not feel confident, will guess, will make mistakes, they'll misinterpret, order the wrong treatment and patients will suffer. Many will avoid the issue. And some will find in it a special calling. That's the state of things.

My goals

Hopefully in this short paper my goal will be two fold. **First** to get a grasp of what does it mean to learn, to teach, to internalize, to test, to reinforce, to retain --- overall to learn ECG interpretation – and the different modes and techniques of learning this art. **Secondly** it's to introduce perhaps one small idea I've been gestating for literally decades: I've seen one small suggestion in the literature but no overt recognition of this simple idea. That idea? In a moment.

How do we good at teaching and reading ECGs? Diving in: the prevailing opinion

Much of the prevailing teaching opinion seems to be you just have to read thousands of ECGs. In fact in the American College of Cardiology (ACC) **Recommendations for Training in Adult Cardiovascular Medicine Core Cardiology Training** (COCATS 3) [1],[18], [19] recommends interpreting at least **3500 ECGs**. This to achieve "level 2 training and be boarded eligible". This is the Cardiology starting place. Being this is the standard for Cardiologists, it raises a very high bar, yet even at this high bar *Cardiology* Fellows in Training (FIT'S) are failing the ecg portion of their tests.

Most foundational ecg training focuses on correlating which lead or group of leads represent electrical activity in which the related quadrant or arterial bed of the heart (e.g. left anterior descending, left main, right circumflex arteries, etc) and causes it's respective changes in electrical tracings. Training links the electrical physiology and the processes or pathology behind it, like pulmonary embolism, ischemia, infarction, slowed conduction etc., culminating in the tracing we've come to know as the 12 lead ecg.

Again the focus here is not to propose all practitioners need to attain the level of expertise aimed for by cardiologists, but to **look at how ecg interpretation is taught.** After a literature review of 35+ odd papers (only of which maybe 17 are referenced here), online educational services, proposed approaches, etc. only one approach actually mentions the term "drawing" in it's program explanation. (And upon looking over this site's description, the emphasis is on memorization and *not actually drawing,* (yet - this still works - its good advice. Just not well represented for ecg's).

Learnable, teachable, visual, observational skills

It is my position that since ecg interpretation **as well as** reading xrays, ultrasounds, CT scans – even doing a physical exam etc – but these are not the focus here, are **visual and spatial interpretation skills.** And being visual skills exactly similar to the visual skills an **artist** trained in realism, contrary to popular belief, in fact are ***acquirable visual skills*****.** Then maybe a short course in ***acquiring drawing skills*** might be of benefit – even be of great benefit in *increasing the accuracy* of ecg interpretation and *shorten the learning curve* for who need to learn them. Maybe a little far fetched? Perhaps.

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Looking at the state of teaching and learning ECGs: Literature Review Introduction - Methods

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What is the breadth of types of teaching?

My method will be **secondary review**: looking far and wide to get a a good feel for what is out there, what are the varying approaches and benchmarks in learning. Exploring any actual numerical data, and experimentation, randomly controlled trials (RCTs) if available, looking for any approach that might ease entry or speed entry to ecg interpretation competence and confidence.

Web search key words and **phrases**: teaching ECGs; ECG interpretation; ECG mastery; mastering ECG interpretation; ECG computer simulation; ECG 3D animation and learning; keys to learning ECG interpretation, ECG interpretation best practices; classroom ECG; undergrad electrocardiography; electrocardiography; ECG flash cards; taking extended links from search findings and tracking results down, secondary and tertiary searches on those findings.

Study Sources

This study involved interrogation of the known medical search engines, peer reviewed and otherwise, Cochrane, NCBI, Medpub, etc, as well as Google, Google Scholar, Yahoo, Bing – anything that might turn up any conventional or novel approach. This search further involved exploring online instructional programs – both those commercial and academic. Claims were explored for data and proof that may suggest e.g. method "A" truly expedited ecg interpretation and accuracy.

Lots of approaches - but not an infinite amount: a brief preview

There isn't an overwhelming amount of differing approaches. What there is is near unanimity in the overall pessimistic view and sentiment about teaching and learning ECG interpretation: "**this stuff is hard to teach and we're really not doing a good job**" and has "resulted in **bad outcomes** and **malpractice** as well as **failed board exams**" even at the level of the Cardiology fellow. Still there are plenty of approaches – and it's stimulating.

Approaches range from the "as expected" field topping expectations of a **Cardiology Fellows In Training (FIT)** residency level ecg interpretative requirements level to even **first year med school** approaches, to even undergrad late **high school**-like attempts (eg in Britain and Europe where med school training actually begins after the US equivalent of senior year of high school.)

Methods range from the typical **repetition**, **repetition**, **repetition** approaches (of course after after a firm understanding of cardiac physiology), to "**kinesthetic** -show-me-the-beat" novel approaches , **3D**-demonstration and internalization approaches. Other approaches diverged in teaching styles such as one-on-one classroom, Internet-only approaches, internet combined with peer-teaching, Traditional large classroom-only teaching approaches, and "the stick works better the carrot" testing approaches.

Stick and carrot, and more

There were those approaches that attempted to prove "The Stick" always trumps "the carrot" (**summative** verses **formative** approaches (two new words presented in the teaching profession lexicon) and those methods that teach ecg interpretation through learning a segment by segment approach (the relatively "novel" Chinese approach called "Graphics-sequence memory Method").

It is the last approach, the **Graphics-Sequence Memory Method** that comes closest to one I have proposed unofficially and informally for over 20 years as an offspring of teaching an online *drawing* method. In particular teaching the drawing of caricatures. And not only that, this program (as seen at YouCanDraw.com – my own site) involves incorporating the methods discovered and perfected by **Dr. Betty Edwards** and as outlined in her breakthrough book in 1978 "**Drawing on the Right Side of the Brain**" book.

In her book and as I have both seen and have been teaching these methods now for 24 years, have a way of circumventing the left brain's tendency to e.g. categorize and name – and thus curtail or block – any further "now time / real time" in-the-moment- moment *observations*.

Though **Dr. Zeng's** approach **Graphics-Sequence Memory Method actually** gets closer to actually brushing up to "right brain observational techniques" than any other of the approaches, at least it was the first to propose it – and with striking results I might add, **yet it only scratches the surface**. But, in my opinion is completely on the correct path.

Yields still bigger benefits

As an aside I also have to note, the benefits of learning these approaches go well beyond reading ecg's – like reading and interpreting xrays, CT scans, ultrasounds, venograms – in fact any test or imaging --- that involves accurate visual inspection. **Why? How?** Because **the methods of observation *are all the same.*** Once learned, they are applicable anywhere. Many stumble on to these, many don't. Many everybody already unconsciously use and has never given them a second thought. Anyone can learn them.

Still *more* to learn? There's already too much!

That said, Undergrad medical education / medical school, PA and NP curriculum are all overwhelmingly packed with too much to learn already. So how to fit this in the curriculum? That might be a subject for a future paper – I won't concern myself with that right now. But **as a hint**, the **DRSB** program actually has a 5 day intensive where students (who are interested) go from drawing stick figures to drawing full, amazing portraits in those 5 days. Seems an amazing if not altogether heretical claim, but this is proven over and over and over again.

We'll start with just ecg's

I am only proposing these methods for reading ecgs - which are more akin to elaborate stick figures and of course nothing like full on portraits by any stretch of the imagination.

With the present day level of even internal medicine fellows, cardiology Fellows and emergency medicine residents agonizing over their own lack of confidence reading ecgs (as well as xray's and other imaging) and the gravity of missing dangerous and life threatening diagnoses, it seems an idea worth exploring. That said, let's look at how reading an interpreting ecg's are taught...

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Reviewing the creme de la creme of ECG interpretation requirements - starting at the high end

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Methods the authors of *Methods of Teaching and Evaluating Electrocardiogram Interpretation Skills Among Cardiology Fellowship Programs in the United States* [1] The authors used an 18 question electronically mailed survey to 198 accredited Cardiology FIT programs. About 90 respondents (48%) to the mail-out testing.

What was discovered there? The benchmark: In **Recommendations for Training in Adult Cardiovascular Medicine Core Cardiology Training** (**COCATS 3**), as mentioned above, interpretation of ***a minimum*** of **3500 ecgs** to achieve a level 2 training and then be board eligible. (70% of respondents thought this was and appropriate number.) Then passing a separate **2 part test section** upon completion of their fellowship within the cardiology board exam required by the American Board of Internal Medicine (ABIM).

Part I is a multiple choice **ecg image analysis**, (where later in the article these images are described as more like the ambiguous tracings you'd encounter in real practice); and **Part II** a 37 question exam of "classic" ecg tracing interpretation. This separate 37 question exam is built around a **94 option answer sheet** comprised of the 94 "classic" ecg tracings. [Appendix illustration 1]

FIT's must pass both sections: if either **Part I** or **Part II** is failed the FIT fails the entire sub-specialty board exam. The authors mention it is the classic ecg section of the test built around the "94 option answer sheet" that throughout training is a point of consternation and the more dreaded part of the testing. (There is a lot on there – again refer to the appendix.)

The 94 option answer sheet

So Cardiology FIT **Core training** is built around gaining sufficient expertise to recognize all 94 rhythms on the 94 option answer sheet. (**See Appendix 1**: this is actually an excellent guide for self review – over time of course, like rehearsing over and over through a career.) The **94 option answer sheet** has been described as the "necessary evil" cardiology FIT's must carry with them through their entire training fellowship.

No standardized learning method actually proposed

What is very interesting in this paper is the acknowledgment by the authors that none of the governing bodies (eg ABIM or COCATS 3) , give any indication about how programs and fellows were supposed to learn these rhythms. There is no method proposed. It's acknowledged its difficult to keep track of the 3500 ecg interpretation minimum – though with cell phones and computer counters / registers, there's some headway. Even less guidelines around how incorporating the 94 option answer sheet is to be approached.

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Time spent per week in lectures:

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What methods were used among respondents

The authors asked the directed question in their questionnaire about **what methods were used** within their programs. The average FIT **ecg interpretation curricula** devoted an average of **11 hours per month** divided among 4 specific areas:

0 to 4 hours core **didactic lectures**
2) 0 to 5 hours one-on-one **tutorials**
3) 0 to 4 hours **interactive conferences**
4) 0 to 2 hours **board review conferences**.

* a smaller percentage - less than 5 or 10 % depending on category, spent more than given upper level of 4 or 5 hours per month on these lectures.

Who teaches the lectures?
Lectures were taught by a cross section of chief fellow, middle , junior or senior fellows sharing the load. Some taught by the cardiology director, some by outside departments, some taught by experienced providers within the sub-specialties of electrocardiography, imaging/noninvasive and interventional cardiology, and general clinical cardiology.

Not much detail about the content of those curricula but it's probably fair to assume they're the usual case presentation, PMH, presenting patient signs and symptoms, ecg interpretation and treatment, and outcome. Much of this in my mind points to rote repetition being the key to mastery. At least that's my assumption – and my own experience.

What's the best method?
Of the above there was some breakdown of curricula (table 2 on page 342 of Cardiology journal) itemizes the following as being utilized: interactive programs, instructors employing ecg's from multiple sources but the most common from the gathered files of the instructors personal collections, educational products, ecg teaching texts. No clear superior method demonstrated in the data but **on-on-one** seemed to be the most favored.

Instructors were generally Cardiologists who were more often program directors who the greatest proportion were drawn from general non-invasive cardiology backgrounds.

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Overall trend: towards weaker ecg interpretation skills: even in cardiology

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The authors note a potentially deleterious drop in ecg interpretation standardization and diminishing emphasis on ecg interpretation skills since the introduction of multiple different **new technological modalities**. New modalities and increasing dependence on ultrasound/echo cardiogram, and new treatments like cardiac re-synchronization therapy, left ventricular dyssynchrony assessment, implantable hemodynamic and loop recorders, complex atrial and ventricular ablation procedures, contrast and 3-dimensional echocardiography, multi-detector computed tomography coronary angiography and clinical vascular medicine.

The irony, the authors note, is **the deeper you go into cardiology** sub-specialties **the more necessary the old fashioned 12-lead usage and interpretation becomes.** It is the early career infatuation by FIT's with the higher income and more hi-tech intense – and therefore more expensive – cardiac subspecialty attractions that detracts from time devoted to ecg interpretation curricula.

The obvious outcome: an **overall diminished level of ecg interpretation expertise** among cardiology FIT's. To quote the authors: “In truth the ECG still serves not only as the gateway for diagnostic testing and therapy in cardiovascular disease but also for fellow education.

Quick summary: Cardiology fellow training in an ECG curricula is built around learning **94 distinct rhythms** that will be tested on one part of a board exam - which you cannot fail; a separate distinct section of the final CARDS bard exam built around the more ambiguous and less than “classic” presentations of tracings taken from day to day rounding and patient care: minimally **3500** to be exact; at least **11 hours per month** of focused classes for the entire fellowship , didactic teaching, one-on-one teaching, computer-based classes, subspecialty imaging and interventional experiences, text book assignments, interactive conferences, direct patient care and all aimed at taking the rigorous ABIM Cardiology board exam at the the end of all that training.

Sounds pretty complete yet the authors still lament overall ECG interpretation is a waning skill when the distractions of high tech imaging, testing and interventional modes have become a seductive distraction. The authors point out the ECG – even after all the new tech – is still the quickest, cheapest, most rapid and probably still the best tool in most situations or for determining when other more hi-tech options are worthwhile.

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So, if that's the highest end of ECG education, what about ECG training for the rest of the rest of us?

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Carrot or the stick

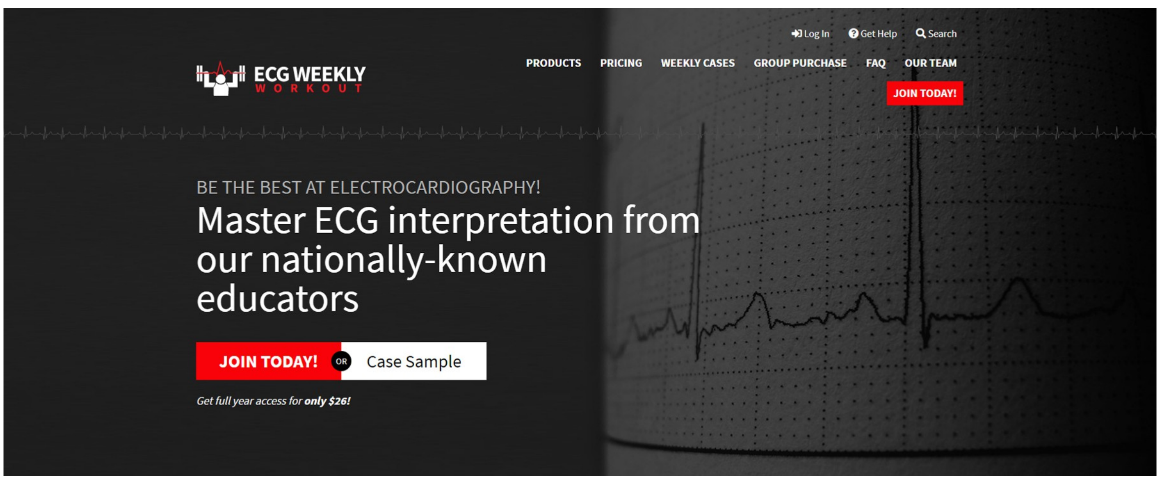
Moving on to an assessment of less rigorous programs, **Graham Fent** et al. [2] **“Teaching the interpretation of**

electrocardiograms: Which method is best?" points out also the disparity, inaccuracy and lack of any peer-reviewed methods of standardization and further, **lack of retention** in many ecg teaching approaches.

The authors (Graham Fent et al) [2] even hint at a certain amount of desperateness in their abstract : they lament **computerized interpretation** may save us form our dismal rate of accurate interpretation by both undergraduate and post graduate practitioners – but acknowledge that the the state of computer interpretation is dismal as well (computerized programs can correctly identify normal sinus rhythm in 95% of cases but non-sinus rhythms at a rate of 53.5 %. And in fact **over-interpret** eg **atrial fibrillation** by 35%. Of which the treating clinician missed the true diagnosis and began initiation anti-coagulation (note 9 in Fent) . It is estimated in another paper (note 10 in Fent) **10,000 deaths** annually can be attributed to **misdiagnosed ecgs**.

No mention in this article of the several normal sinus rhythm dysrhythmias (eg complete heart block, Brugadas, Wellens pattern / syndrome, etc,) that are lethal but will not be detected – and Brugadas and Wellens pattern / syndrome generally considered too advanced to try to teach novice interpreters.

The authors are hopeful computerized interpretation will someday even replace flesh and blood clinician interpretation. **Dr. Amal Matu** at University of Maryland Emergency Medicine program and author of ECG Weekly (now **"ECG workout"** https://ecgweekly.com/) has described essentially all ecg computer ecg interpretation programs as "written by and set up to trip you up by malpractice lawyers"). Humorous but patently quite scary. Not to mention if you're the patient.



In the mean time: Some fascinating observations by the authors: whereas Cardiology Fellows in Training are expected to read a minimum off 3500 ecgs in their training the authors note the American College of Cardiology recommends if ecgs cannot be interpreted by a qualified cardiologist and if not available, **a reader** should have red a minimum of 500 ecgs.

What's a minimum level of expertise – for the non-cardiologist?

In this paper [2], it is pointed out the ability to correctly identify life threatening conditions is successfully achieved by as high as high as 57 % in one US group of medical school grads and and down to 46.4% in a group of South African medical school grads. In other words a little better or a little worse than flipping a coin. [3] .

A **worthy goal** often expressed by many programs (Nursing, medical school, PA and NP schools) and seemingly common sense, would be to have the **ability of recognizing the life-threatening dysrhythmias**. At least upon graduation.

How to achieve this goal? In time and with practice hopefully most clinicians will eventually achieve this actually lofty goal – that has been pretty much taken for granted – but often never materializes. . Something is awry on how ecg education had been taught. So the question is how do we make it better?

Multiple methods: workshops, conventional lectures and self-directed studies

The authors make the claim poor ecg reading skills in post graduates is most likely from poor or non standardized undergrad teaching. Whats the gamut of teaching methods employed? And is any one method, or is no one method best? students have different approaches to learning and learn better in some situations than others. The authors essentially winnow out different methods down three main categories:

1) **Lectures** (75%) then teaching rounds 44% - included in “lectures”)
2) **Workshops**
3) and **self-directed learning (SDL)**

Fent's et al study [2], focused on this. A study of 211 randomized US medical students were divided within those 3 categories. All content was was evaluated for having identical content, all students were given the same baseline “pre-instruction” assessment tests, all used identical ecg examples.

Advantages of each category: **Lectures** and **workshops** allowed more interactive exposures to students and instructors, there was more direct feedback. **Self-directed programs (SDL)** allowed the convenience of studying when an where a student had the time or desire, and could refer back to the materials as desired.

Workshop and lecture based programs received 2 hours of teaching; the SDL group was instructed to study for 2 hours.

All 3 groups scored approximate the same on the pre-course test.

However In the i**mmediate post course test results** (ie after the 2 hours of teaching) the lecture and workshop groups scored significantly better than sis the SDL group (mean scores 57.3%, 56.8% and 48.8% [p-value 0.003])

Retention tests (ie testing 5 months after the original “intervention”) showed a similar proportional result but all respondents had a drop their scores.

Further distinctions between learning approaches

Further delineation of different learning approaches : **SDL** had the “convenience bonus”: you could study when and where you wanted – but this was reliant on learner engagement. **Workshop** training is generally more face to face, could be tailored to the learner, could be more time intensive – bet resulted in better retention; **Lecture based** was the most standardized but harder to ascertain how much and who is absorbing the information.

Additional web based programs were promoted also to further promote student learning – especially after the post instruction testing. From **Youtube.com** to university to private vendor created sites. All proved to span across a spectrum of informational accuracy to even misinformation (as determined by cardiologist review). There was no correlation between accuracy of information reflected in YouTube “likes” and the accuracy of information given. Very interesting.

Contrastive versus non-contrastive approaches *

Most significant to me were the use of **contrastive** and **non-contrastive** teaching approaches: **contrastive** (page 192, second column, just above the conclusion in [2]) being where you contrast different dysrhythmias across different diagnoses: this promoted pattern recognition whereas *non-contrastive* approaches ecg dysrhythmic patterns and diagnoses were taught individually and sequentially. *Seems logical* but the *contrastive* proved to be more efficacious and resulted in more accurate interpretation.

More carrot and stick

The other fundamental discovery (not really surprising) by the authors was the weight any one of the above approaches and their associated test scores might **weigh on their permanent record** . This was termed **"formative"** versus **"summative"** scoring.

Formative scoring was a measure was an evaluation of students understanding of the materiel given after each lecture (and some direction given "you were a little weak here, study this more, your sinus rhythm interpretations were rock solid").

Summative scoring however carried much more of a stick: whether after a chapter or a block of study a test was given: it was known by the participants every one of these sections would add up to their permanent grade or record. **Huge insight:** who do you think scored better? Of course those subjected to the summative approach.

Lastly the tests given in any of the approaches (lecture, workshop or SDL) actually required only 3 out of 5 correct answers on ecg recognition to score favorably. Of course the summative group did better (they studied harder for the test – grasp that. And were allowed to use any additional online or traditional tools to aid in studying for the test) .

Rhythms studied

Compared the 94 option answer sheet cardiology fellows are required to learn, in this study (and in fact most like it) *studied these categories: myocardial infarction, bundle branch blocks (left and right) , pericarditis, and ischemia. It seems to me 'quantity of rhythms-wise' the bar is not too high (yes these CAN be subtle and complex rhythms. Recall, the goal is to train new clinicians to recognize and not miss the most potentially lethal rhythms.

*__Note__: you'll see these light yellow highlighted text in several places in this paper. This was for quick visual scanning of the paper when looking it over for rhythms used most commonly in various programs.

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Next: Exploring new 3D technology in the comprehension and understanding aiding in the acquisition of confident ECG interpretation

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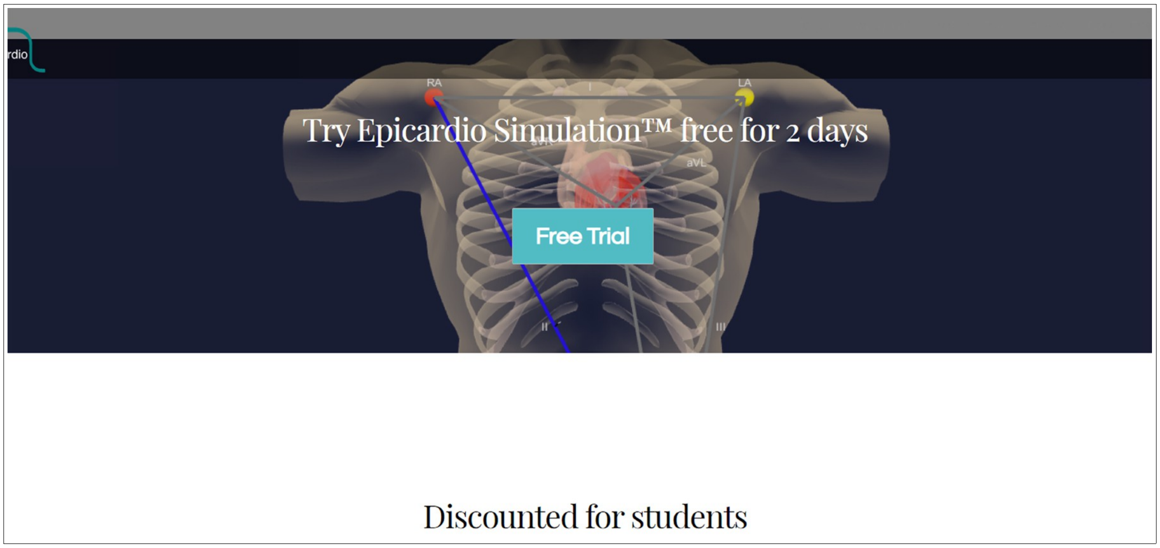
Titled "A randomized control trial comparing use of a novel electrocardiogram simulator with traditional teaching in the acquisition of electrocardiogram interpretation skill" https://pubmed.ncbi.nlm.nih.gov/26709105/

The motivation again: with the stakes so high in interpreting ECG's correctly and the outcomes so poor, is there a better way to teach learning ECG interpretation? Lets look at the incorporation of newer technology applications:



The star: **Epicardio simulation 3-d software.**
http://www.epicardio.com/
http://www.epicardio.com/cardiology-simulation/ --- 2 days free trial
check it out at youtube:
https://www.youtube.com/results?search_query=epicardio+cardiology+simulation

In short – insufficient evidence produced in this trial to say if better than conventional lecture (but only 45 minutes lecture in either arm: Classroom lecture v. computer only program); but amazingly very nearly as good (The authors in their conclusion do not mention that.) A discrepancy: page 115 of journal states insufficient evidence to say “if equivalent” whereas in the abstract say insufficient evidence to say “if superior”. The mean of this study may not be as good but is not statistically significant. ..so kinda weird. Is this a less than thorough proofread test?

The Fent follow-up was the ecg computer simulation - what's better: classroom or computers?

Two groups. group 1: given one 45 minute lecture and group 2: served a 45 minute computer-based program. Anyways, test was set up like this: both British medical school undergrad students years 3,4 , and 5 and first year post grad MD “junior doctors”. More details than given in the following groupings but essentially:

Group 1: 45 minute small group teaching arm received 45 minutes ECG tutorial in ECG interpretations taught by 2 experienced Cardiology “Registrars” (registrars from what I can gather are the equivalent of American senior residents)' all participants in this group could ask questions about the material, ecgs. rhythms, fine points etc of diagnosis.

Group 2: Given 45 minutes to work through an interactive computer program: it consisted of exemplary 12-lead ECG's of all the 10 given diagnoses above. Each student had their own computer, could only ask computer related questions but no questions allowed about the ECG's nor about the content.

10 different rhythms - NSR, RBBB, Inferior ST elevation, Mobitz type 2 2:1 Atrio-ventricular block, Atrial flutter, Ventricular tachycardia, hyperkalemia, left ventricular hypertrophy, ventricular fibrillation, sinus tachycardia.

No pretest given to get an idea of ecg interpretation competency but immediate post tests showed scores were higher in the lecture group than I the ecg simulator group - though not a statistically significant difference. (85 students in the computer group, 83 in the lecture group; Statistical analysis incorporated a Shapiro-Wilk's test, visual inspection orf histograms, box plots, Q-Q plots; independent t-tests were used to compare questionnaire scores)

A "**Likert scale**" was also performed (eg "did session boost confidence in ecg interpretation? Was it a useful way of teaching? Did the session improve your ecg interpretation skills?", participants rated on a scale 1 to 5) . Results of this Likert scale showed show no difference between groups in confidence; the lecture group received slightly higher scores in both usefulness rating and improvement in interpretation skills – but again not enough to be statistically significant.

Retention. That is, how much of the lesson was retained, recalled, could be successfully referred back to the teachings by participants 3 months later was also of interest to the researchers. **What was found** was no real difference between groups. There was a fall off between both groups in overall scores - as expected. The authors mention a few things that might influence retention: the retention test was taken under regular testing conditions, nor was it mandatory. With a little "real world" test pressure scores may have been higher (since students normally review material before a test that "counts") but the authors were shooting for a purity of retention.

They also note, in a computerized world, **the whole advantage of computer access** to lessons allows for convenience and repeat exposure to the material as the student wishes. Very advantageous in more and more splintered educational life. This sort of access was not granted in this experiment – so may under estimate its power.

There were other criticisms and short-comings concerning the software, but the authors interestingly mention the computerized lesson could be "**made to accommodate the visual learner**". I have no idea what they meant there since it seems to me so much of working at a computer is visual. But I was glad they mention the visual learner – it will weigh well in my proposal below :-)

Looking at the software itself: there is a 2 day free downloadable version: **http://www.epicardio.com/** – Much is also on **youtube**: **https://www.youtube.com/results?search_query=epicardio+cardiology+simulation** this video is at least narrated: https://www.youtube.com/watch?v=iuFytZ_Mw88

After watching the you-tube version: https://www.youtube.com/watch?v=iuFytZ_Mw88
Is a really wonderful, well done production. Will it improve teaching goals?

After downloading the test version:
Beautiful graphics, beautiful 3d simulation, shows multiple layers: from muscle anatomy, nervous anatomy (IE the bundle of HIS, bundle branches, anterior and posterior fascicles, yes you can get a wonderful idea about how the ecg tracings correlate with what's going on physiologically in side the heart. You can slide the "now time" handle back and forth as slow as you'd like, switch to the full body view and observe the changes in q-wave, to R-wave to S-wave, as the contraction signal traverses through the heart towards eg. lead II and watch the build of the r-wave, it's peak as the signal passes under the lead, and the downward plunge of the S-wave as the signal passes beyond the lead.

Pretty amazing and very well thought out. You can watch this kind of depiction for multiple conditions. (The nerve signal conduction – as does blood flow – appears more akin to small dust storms traveling through and around the heart rather than real fluid flow. That's my only criticism.)

Does this help you READ an ECG though? And correctly interpret it and assign a treatment plan in the moment of encountering an ill ACLS patient?

[*there are 31 or 32 different rhythms explained and animated in Epicardio, and correlated almost exactly with the 31 or 32 rhythms mention in the **Jablonover, Stagnaro-Green "Entrustable Professional Activities"** study below – half of which 3rd year medical residents are *not* expected to know]

I enjoyed the program but its been too long since my initial training days to know if this would be helpful. Its not like you couldn't envision everything the 3d program demonstrated in your own imagination - before the days of 3d demonstrations. Imagining it in an "old school" fashion certainly was more work I think. Nonetheless I enjoyed it. I look forward to a day when I can spend more time with it.

Regarding the note above ("**could made to accommodate the visual learner**") – I now know what Fent et al are referring to: when you click on a condition (eg WPW), you get 6,7,9, upwards of 40 different pages that show up in the left upper corner, They're wordy notes done in white text against a dark background (classically recognized to be difficult and straining to read – as it is). I found myself very impatient (I'm probably a visual learner).

All in all looks like a very interesting program, but I've been doing this long enough where I think I've built in my own 3d visual map of nerve conduction and blood flow and how it looks as both signal and blood traverse the heart - so I'm not a good subject. I did the 2 day free trial – my computer does not have the power to do the program justice. Someday I'll look at again with a more powerful computer .

** one other unusual and very interesting critique of "all things offered up visually": when you divorce the unconscious or even the visual brain from the effort needed to conjure up the brain's own multi-sensory production, **you deprive it of its own creative development**.

No imagination needed

For example, you watch Hollywood's latest reproduction of the movie "Moby Dick". Everything is delivered to you literally through your eyes and ears. **No imagination needed**. If however you're reading the book, the words pass through your eyes, where the meaning is applied by the frontal cortex, where that meaning is attached to your own whole personal pool of memories of "all things, whales" and sea battles, oceans, ships, ropes, harpoons, spouting nose holes, man against nature, nature against man, man against man, harpoons and spears and blood and giant octopuses and the bottomless Marianas trench and ocean gales and old wooden frigates and whaling ships, and rugged wailing crews and eating in a candle lit yawing and pitching ship belly mess hall with groaning timbers ...etc.

And all that is passed back unconsciously through the visual cortex and offered back up to the conscious mind: a much more satisfying effort – emotionally and cerebrally and imaginally – this has instigated and coordinated. But that's an aside. **A related aside as you'll see below** – but an aside.]

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Our goal again: what is / are the best method or methods of teaching and retaining ECG interpretation that will help save patients lives?

(this is good for seeing how a test might be set up! And how new knowledge might be tested – things I hadn't thought through))
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There's a saying the Orient. I heard this somewhere when I was in my early 20's from a general surgeon from Taiwan: "In the west you try to learn everything from the neck up. In the East we try to learn from the neck down". **Translate:** learn by using your body, not just your head. In the **West** you learn from head up, in the **East** you learn from the head down.

This is a great segue from the 3d animation program above **Epicardio**, to the next paper titled "**Show me the beat**":

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"Show me the beat"[4]

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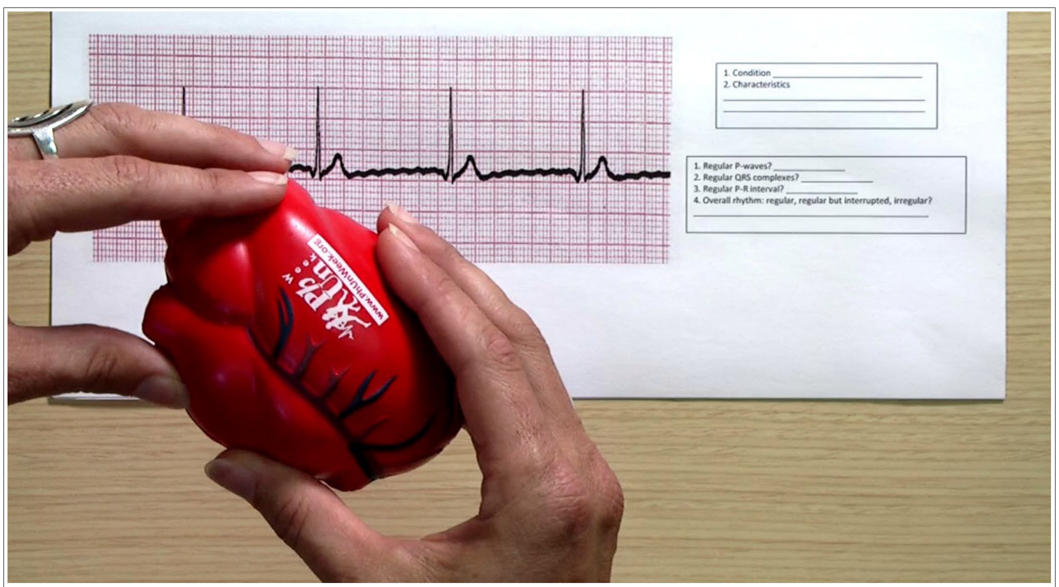

Illustration 1: The "show me the beat" squish ball heart and ecg tracing

and** I suspect building the program you'd gain the most!

In this study "**this kinesthetic activity** is designed to help students better understand the link between cardiac electrical events and cardiac contractile events". The test was set up as one 2.75 hour laboratory demonstration and teaching within a 10-part human physiology series. It's been identified as the most popular of the 10 part series and as would be expected is a class taken by students (undergraduate) aiming to go on into the health care professions.

The course director incorporated this class secondary to multiple comments from students how it would be instructive to get a better mental connection between electrical physiology and moreso pathological electrical conduction and the functional consequences of distorted conduction through the heart and on cardiac output. In fact he found students graded poorly on that part of the exam that tested the connection between *altered* electrical and cardiac function.

Students had a reading assignment and quiz before the actual demonstration. They'd watch an MRI recording of the heart and an echocardiogram film before the actual "hands-on" class.

The essence of the class was this: the demonstrator stood in front of the class holding a "squish ball" representation of a heart. On the wall behind the demonstrator was a large projection of an ecg. As the demonstrator (will just say "he") literally walked left to right at the front of the room, behind him was the enlarged ecg (of lead II) .

As he physically walked in front of each ecg segment projected on the wall, he squeezed the appropriate part of the squish ball heart that was activated by the electrical tracing. For example, at the P-wave: he'd squeeze the atria; at the P-R interval – no motion; at the QRS he'd squeeze the equivalent of the ventricles; at the ST interval he'd announce the heart would be recharging, etc. and he'd keep walking as he'd pass the T-P sections the heart would be in apparent relaxation. Link to short video showing the process:
https://mediaspace.msu.edu/media/Pathological+ECG+Diagnosis+and+Show+me+the+Beat+Video+Suppleme nt/1_rscqm7uh

Then the class was broken in to groups of four. Eight ecg's were divided up between the groups. Each group was to:

1) walk through the "squish ball" heart demonstration for their given tracings, (ie "show the beat" for each tracing);
2) predict what each tracing amplitude would look like in each of leads I, II, and III;
3) predict the effects breathing – inhalation and exhalation -- might have upon amplitude conduction, and
4) predict shifts in axis conduction again breathing.

Lastly a representative from each group would present the findings for the class as a whole.
The 8 ECG tracings were:; **1)** atrio-ventricular junctional rhythm; **2)** ventricular rhythm; **3)** first-degree heart block; **4)** second degree heart block type 1 (Mobitz I / Wenckebach); **5)** second degree heart block type II (Mobitz II); **6)** atrial fibrillation; **7)** ventricular tachycardia and **8)** asystole.

In small group students were also given **four diagnostic questions to help evaluate** their given rhythms:

1) are there regular P-waves;
2) are there regular QRS waves;
3) is the P-R interval regular (too short, too long, etc., and
4) is the overall rhythm regular? regular but interrupted? or irregular?

What the authors were most proud of at the end of their demonstration was the integrating of the electrical tracing (the ECG) with a hands on kinesthetic sense of cardiac patterns and physiologic conduction – and its real world / real tissue effects. The authors felt students had a better idea how dysrhythmias affected cardiac conduction and gave students the ability to visualize how electrical patterns influenced the heart.

Nice to have a pre-made rubber heart but you could build your own with a tennis ball - divide into atria and ventricles by just writing “atria” and “ventricles” right on the ball. Or build a heart mock up with pillows or even balloons and walk through this by just using imagination against a rhythm strip.

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On to a new paper: Moral connotations - ECG as an Entrustable Professional Activity: CDIM Survey Results, ECG Teaching and Assessment in the Third Year

[5] Robert S Jablonover 1, Alex Stagnaro-Green 2

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In this paper the authors harken back to a prior paper from 2005 where they surveyed both medical schools and PA programs. It was identified in tehbn2005 paper the both PA students were lacking in their ECG interpretive skills. They repeated the survey in 2013 and included Internal medicine programs - focusing on the best place and time to ECG reading skills.

Also during this period Medical Education at large had been going over their own focus on what are now defined as **EPA's: Entrustable Professional Activities**. They identified 13 of them. **ECG interpretation** is defined as one of them. Yet, identified as a skill graduating MD's are expected to have, interpreting ECG's has again proven to be wholly short in satisfying that expectation.

The authors wanted to look back over the 8 years following the 2005 study and determine if any improvement. There was little or none. Suffice it to say if newly graduated MD's and PA's are selling themselves as adequate ECG interpreters – but are not – there's an issue. Especially when misinterpretation carries such a high cost in lives lost and misdiagnosis. If not satisfied by the end of 3rd year of residency, then when? How is ECG reading assessed? And when / how does the education take place, and is there / are there areas of ECG tracings that ought to be focused upon?

Authors methods

Through mailed 68 question survey, telephone followup, 3 additional email followups, the authors submitted their 18 question survey through the Clerkship directors in Internal Medicine (CDIM) for distribution. 13 of the total 68 question survey focused on ECG assessment ans interpretation.

The results:

94 of 123 schools responded, (76%) ECG instruction was reported to occur in the 3rd year of residency in 85% of the programs. The ECG patterns taught varied widely (see below); Instruction was taught by clerkship directors 51% of the time, 37% by the cardiology “division”, 23% by the ward attending.

Time devoted to teaching ECG's

Most schools reported 1 -6 hours on “formal ecg didactics”, but dedicated hours had wide variation: the full range of time: 1 – 10 hours, 33% dedicated 3 -4 hours of formal training, 28% of schools supplied 5-6 hours, 18% 1 -2 hours, 4 percent on 6 or more hours. (As an observer this seems surprisingly little – but in retrospect does not vary markedly form what I recall about hours of formal classroom time I had in PA school. May have seemed more since this does not count time studying outside of the formal teaching).

How taught

A variety of teaching arrangements: 62% in lecture, 55% in small group sessions, 30% assigned readings, 22% formal teaching rounds, 18% web based teaching modules.

How many ECG formally required of a resident to interpret
Fascinating responses here: 37% of respondents reported a student was formally requested to interpret > 10 ECG's during their clerkship / rotation; 24% said they didn't know how many a student had to interpret, 1 % said only 1-2 ECG interpretations were required formally; 4% said 3-4 interpretations; 9% said 5-6 ECGs; and 6% of respondents said 7-8 ECGs.

In the 8 years between the 2005 survey and the 2013 survey – though cited as an area that requires real change and improvement – none or little took place.

Barriers to changes and improvements:
Barriers to improvements: the usual suspects: lack of budgeted time, lack of teaching faculty comfortable and confident teaching ECG interpretation (12%); written off to presence of ECG instruction at other points during med school.

What is taught:
The authors relate respondents (almost 100%) contend internal medicine residents all students **ought to be able to recognize** the following ECGs:

sinus rhythm
sinus tachycardia
sinus bradycardia
atrial fibrillation
atrial flutter
first-degree AV block
complete heart block
premature ventricular complexes
ventricular tachycardia (monomorphic)
bundle branch block (does not say left, right or both)
left axis deviation
left ventricular hypertrophy
ST-segment elevation myocardial infarction
acute pericarditis, and
hyperkalemia

(54% indicated students **ought** to be able to recognize long QT-syndrome).

On the contrary, the majority of respondents **did not expect residents to identify** - by the end of their residency - the following:

torsades de pointes
Mobitz 1 and 2 blocks
myocardial ischemia
pacemaker / paced rhythms
ventricular fibrillation
non-ST elevation MI
multi-focal atrial tachycardia
polymorphic V-tach
electrical alternans
AV nodal reentrant tachycardia
Wolff-Parkinson-White syndrome, and
left anterior curricular block.

Testing

Again a variety of assessing resident knowledge on ECG interpretation. 42% of responding programs stated 3rd year residents were given no assessment. (Notably 15% of respondents left the question blank.) in programs where residents had assessments, written exam stood out in 24% of the programs. Other modes: 14% had assessment during an overall clinical exam scenario (ie in actual patient care); 8% in computer exams.

Final analysis by respondents: 65% of directors felt their training was adequate. 22% avoided the question; the remainder had no strong feeling in either direction. **No program director would say their ECG interpretation training was inadequate.**

Some fine points the authors garnered from their study: little will or ability by residency directors (because of too many other demands) to change or upgrade their ECG training; There seemed to be **wide agreement the above 15 or so ECG's identified were the minimum** residents ought to be able to recognize upon completion of their residencies.

Formalized requirements really ought to be implemented if ECG is really going to be considered an **Entrustable Professional Skill**. Newer and more innovative programs could be incorporated (like electronic or web based education – that can be accessed anywhere or at any time – eg **Maven ECG online**)

https://ecg.bidmc.harvard.edu/maven/mavenmain.asp
https://www.facebook.com/EcgWaveMaven/

Small group peer teaching (see Raupach et al [10], [11]) is very effective – moreso than lecture based.

Its recognized everywhere and underscored again here ECG interpretation **mastery is a repetition-based skill**. Building the repetition and exposure – and getting over the intimidation many feel when learning - is a hard won skill. But necessary especially if internal medicine residents (and PAs) are going to sell themselves as proficient and confident as patients expect them to be.

It is no surprise many students are not able to identify many common ECG abnormalities – yet their residency directors believe and promote they have (or at least should have) these skills. What is most surprising (I thought) was every respondent residency director claimed the ECG education at their program was adequate in spite of the overwhelming evidence to the opposite.

It is promoted lastly by the authors there needs to be systematic assessment of ECG interpretation and teaching contributions from eg active cardiologists, electrophysiologists, fellows, devel0opment of a more "vertically integrated teaching approach" threaded through medical school and through all 3 years of residency.

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Next Paper:

ECG interpretation skill acquisition: A review of learning, teaching and assessment [6]

C J Breen 1, G P Kelly 2, W G Kernohan 3PMID: 31005264 DOI: 10.1016/j.jelectrocard.2019.03.010
https://pubmed.ncbi.nlm.nih.gov/31005264/
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In this papers the authors Breen et al., Do an excellent job of trying to grasp the the spectrum of teaching approaches – it's not exhaustive – but probably cover the majority of teaching approaches used in PA schools.

Medical schools on up to Cardiology fellowships.

The paper begins with a quick outline of the **development of the ECG** from Einthoven's life work of recording and calibration of cardiac electrical activity in his rarefied coronal plane approach. (**Einthoven** was the one who reduced multiple leads down to the 3 lead (leads I, II ,and III), we're most familiar with today. The authors outline the contribution of **Wilson** (the researcher who added leads V1- V6 in the anterior transverse plane) and lastly the contribution of Dr, Emmanuel Goldberger in 1942 who further helped reveal electrical "blind spots) with the addition of leads **aVR**. **aVL**, and **aVF** ("a"the augmented leads).

The 1940's through the the 1970's brought advanced in direct writing ECG equipment and by 1970 the digitization of the ECG signal making it "the most commonly used cardiovascular laboratory procedure for patients presenting with cardiac complaints" (Ibid Breen).

The problem - **no standardization in the teaching and internalization**
of the skill of ECG interpretation

Breen outlines a common complaint: even with the standardization of ECG recording techniques, there is **no standardization in the teaching and internalization** of the skill of ECG interpretation. **The problem with that?** Acknowledging learning ECG interpretation is a difficult skill to master - -taking time and clinical familiarity – without even some standard approach to teaching ECG interpretation we're stuck in this predicament of generally of a provably poor level of ecg reading skills among clinicians. This has lead to consistently poor outcomes, even deadly outcomes for patients.

At the top of the list of **"should be" best ECG readers** are **cardiologists**: getting 53% to 96% of interpretation correct (just 53%?). Non-cardiologist interpretation falls to 36% to 96% (with a mean much lower n the cardiologist group). **33%** of of ECG interpretation contain **errors of major importance**. (Non-cardiologist readers range from nursing students, nurses, PAs, NPs, non-CARDS MD's, EMT's paramedics, lab techs, etc.)

Groups like the American Heart Association (AHA), the American College of Cardiologists (ACC) are attempting to standardize requirements for ECG interpretation competency and bring it to a level of proficiency both the public assumes clinicians to have and the gamut of teaching schools try to claim their students leave their programs with.

Proof of poor skills:
Breen et al point to further research, eg, among **cardiologists** - the supposed experts - there is disagreement in interpretation; report of accurate STEMI diagnosis (dx) ranges in one test at 79% accurate to another test displaying a range between 87 to 100% [Bond et al study]. (93% accuracy reporting arrhythmias by Sibald et al, and as low as 71% from the Bond et al study ([43]– believe included in the late arriving study in Sept 2020 – which I did not read)

Artifactual misreads, dextrocardias, Long QT syndrome (only 25% detected), and lead placement misreads round out the bottom of the curve. Some of the most frightening statistics regard the misinterpretation of **atrial fibrillation** – both by machine overreading and human interpretation - - which have lead to scores of deadly outcomes [eg. by over-anticoagulation when in fact the patient never had the atrial fibrillation and in thrombotic seeding secondary to missed afib].

Since cardiac arrhythmia and cardiac ischemic episodes and syndromes compose the majority of hospital ICU admissions we ought to have this down better.

Education: the authors beef

The authors are very critical of the most standard ECG interpretation approach. This is the traditional practice of memorizing ECG wave morphology patterns – rate, axis, rhythm, etc. and the conventionally accepted wave forms of the most common pathologies. They characterized this as the lack of understanding "**spatial electrocardiography**" - the understanding a student may acquire if they could correlate better the abstracted ECG tracing with a visual sense of how those tracings correlate with actual myocardial contraction, nerve impulse wave and a sense of the resulting blood flow through the hearts architecture.

(as outlined by **Hurst : "...pattern memorization versus the use of vector concepts"**] – seems an argument made here for the likes of the **Epicardio.com** program mentioned above. More on this below.

Computerized interpretation
With such a poor showing by human interpreters many "expert" cardiologists and ECG tracing companies combined efforts to install **computer algorithms**. These were **built from** a foundation of **cardiologist-agreed upon ECG tracing** pathologic morphology conventions an ECG machine could be programmed to recognize. That is, it, the machine makes the interpretation for you – as part of the tracing interpretation we all see. **The results?**

1) more clinician over-dependence on the ECG machine's interpretation and;
2) a further degradation of at-large medical community ECG interpretation skills.

In fact it has been cited very often the ordering clinician not only has not reviewed the ecg him or herself, but has allowed treatments to be initiated be based upon the computer interpretation alone. Pretty striking.

Add to this in the last 20 years the explosion of new technologies like ultrasound, MRI, and CT – all pulling still more teaching time away formerly devoted to ECG interpretation. Comparatively the ECG – the most rapid, most easily accessible, cheapest, least invasive and arguably the best rapid modality for cardiac assessment – has degraded yet more across our professions.

The densest part of this very dense paper: back to teaching, learning, and assessment practices: so, how many ECG's do you need to read to get good? Answer: quantity does not get you quality apparently.

The authors list a number of proposed programs and estimates for quantities of ECG exposure to achieve proficiency. At the high end: a **16 week program** that proposes reading 11,000 ECG's gets you proficient. (that's 688 ECGs a week and works out to about 34 thousand a year).

The authors mention the paper briefed at the start of this paper: the **COCATS 4 Task Force 3** recommendation (which the authors don't mention as being a recommendation for Cardiology Fellows in Training (FIT) students.) Which again recommends 3000 – 3500 ecgs over 36 months – or ~ 1000 ecg's a year.

The **AHA** and the "Clinical Competence Statement on Electrocardiography" from the **American College of Cardiology** state a minimum of *500 ECG's are required in a 12 month period* to attain ECG interpretation competency – and 100 per year to maintain competence.

Amazingly this study only found moderate correlation between number of ECG's read and years studied. – suggesting length of time training does not correlate with accuracy of ECG interpretation skills.

Training / teaching arrangements are spread out between **lecture** groups (75-90%) supplemented by **small group** and **practical teaching** (44 – 78%) with "ECG rehearsal".
What is most revealing is - or at least very closely looked at - the **most effective and highest scoring results**

come from assessment that's “**summative**” – that is as opposed to “**formative**” assessment where you get guidance at incremental steps on the learning path. Summative is a test at the end of a defined section where your grade has an impact: the grade. And that grade goes on your permanent record. (“the Stick”). Doesn't seem like any great insight but nonetheless fear and pressure seem to work.

Also sited is ECG reading all by itself, regardless of numbers ECGs read, if not connected to a clinical situation is much less effective and has demonstrably less impact.

How taught

The traditional method, most widespread, the classical approach – and the ideal instruction – involves, manuscripts, textbooks, written materials taught in an analytical framework. The most common framework being the “**systematic approach**”: examining the tracing to evaluate and analyze in an order :

heart rate,
cardiac rhythm,
cardiac axis deviation,
chamber hypertrophy,
signs of ischemia,
and calculation of timing intervals
(ie PR segment, QRS width, QTc interval, ST segment).

Further, authors compared work-shop based, lecture-based and self-directed learning (SDL). All approaches proved worthwhile and provably improved interpretation skills but **lecture-based** and **workshop-based** proved to yield statistically significant increases in interpretive skills over SDL formats. (p-values showing small but provable gains).

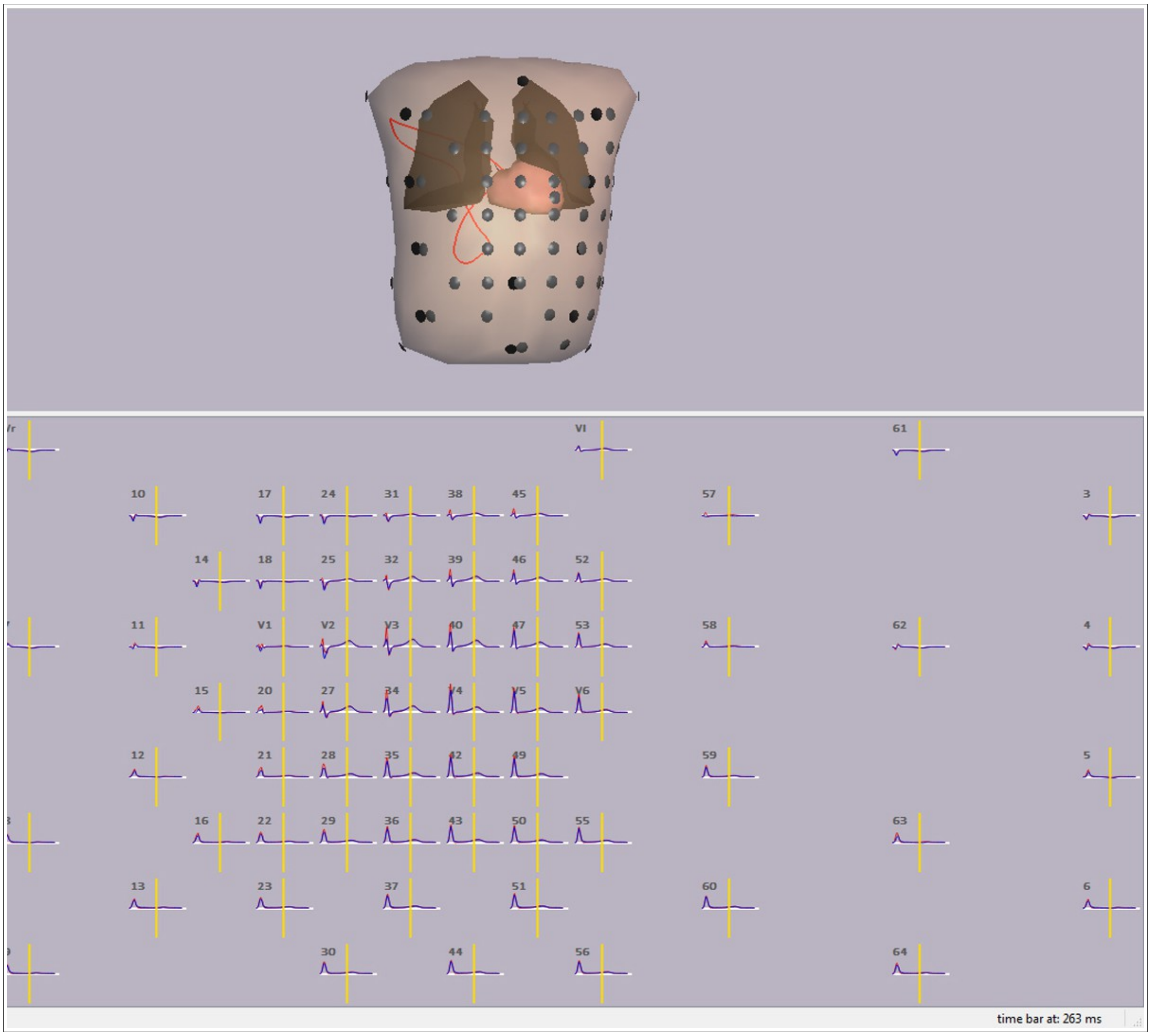
Innovative approaches

The authors are open to all approaches but their goal is competent skills accomplished with the least amount of investment in time, training, and lecturer burdens. In this section they again promote the connection between having an internalized understanding of abstracted ECG tracing morphology and the “actual three-dimensional nature of the heart”

They promote using something like **ECGSIM** - an interactive **graphical** 3d simulator that maps the ECG tracing to a visualized model of electrical impulse and the resultant contraction of myocardium / blood flow – and how it's dysfunction in pathology – actually looks as it occurs in traceable electrical waves throughout the heart. (Very similar to Epicardio.com above – actually an earlier version since this paper predates the *Epicardio.com* paper above **http://www.epicardio.com/ecg-elearning/**)

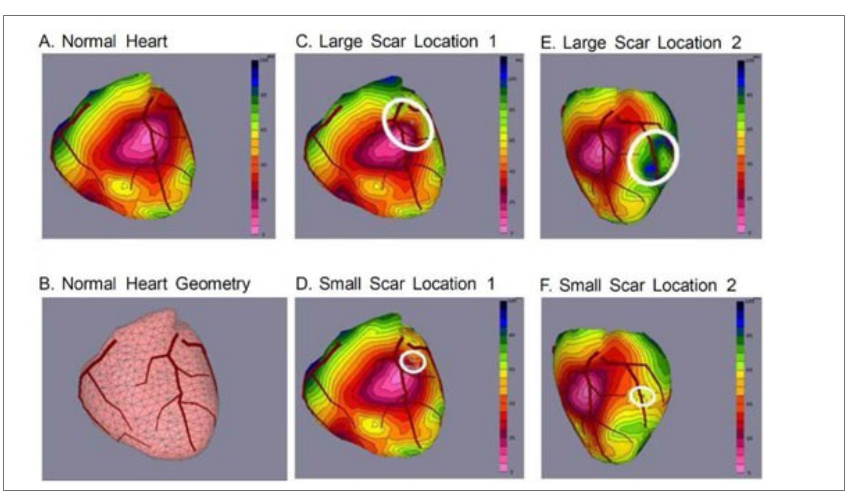
They in fact cite a paper that shows improved interpretive skills in students using the ECGSIM tuition - link below. (I tried the software – very interesting, takes some serious experimenting, constant restarting of each tracing before you understand the timing, to where you *get* what exactly the video is showing.

For instance it took me a little time to realized the completely rewound animation is actually starting in the middle of the PR segment – so **no p-waves**. Thus the ECG tracing is only of ventricular response. There are also options you can switch instantly to for just a single lead ECG tracing, a three lead, a 12 lead and then to **Nijmegan-64 lead option** (see illustration below for screenshot) where I had an “aha” moment that helped make sense of why 12 leads works so well well and why the placement of the 12 leads makes sense.



Approximate Nijmegan-64 lead placement pattern on thorax above; ECG tracings below

There are now options you can access on-line that show different pathologies. I suspect there's a lot more explanation on **youtube.com** and when I have the time I will look; I found ECGSIM had many fewer glitches on my operating system than Epicardio.com. The site again: https://www.ecgsim.org/ **; A thought:** if combined with the Epicardio.com 3D *text* explanations, could be really informative and together could wonderfully fill a



gap in getting a comprehensive and integrated understanding. If you have the time and motivation.

Illustration 2: ECGSIM.org

Other novel teaching measures and tools –

The authors really do a good job looking at other novel approaches: they mention in passing a feedback tool involving "**eye-tracking profile data**" [20]. using eye-tracking software. I find this fascinating and very relevant to my premise "eye-tracking software" – though they don't explain it – is obvious to me: its a measure of how much a reader is looking around the paper, possibly looking at all 12 leads not just getting stuck on the most obvious pathological leads (or often more likely – getting stuck one lead, one singular lead) – and thus jumping to conclusions before looking at all 12 leads, and presumably looking even closer at more minute marks in the tracing. I won't assume this – because most clinicians won't look unless they KNOW to look for these – which is an argument in favor of memorizing pathologic patterns. Dysrhythmias and irregularities like crochetage patterns, atrial flutter and fibrillation waves, and especially extremely subtle tracings like Arrhythmogenic Right Ventricular Cardiomyopathy (**ARVC**) – again astute visual inspection.

[I did skim the article – which was in incredible test methodological detail. **What the researchers essentially found:** two groups. **Group one** the ECG readers who had by far, obvious an clear accuracy rates (the correct interpretation group, interpreted in a much shorter period of time; and **group two**: the group who scored multiple inaccurate reads, were slower at it, etc. Certain diagnoses were easier to correlate also. For example, he "correct interpretation" group the investigators discovered with the eye tracking software their eyes went specifically to anterior leads in an anterior MI, then in order, went to leads most commonly known to have ST depression. Or in the case of a lateral MI, exploring leads leads V5 and V6 and then went to lead I and aVL.

All this suggesting they knew what they were looking for and did it in a specific order. They did not get log jammed on one lead line many in the incorrect diagnosis group. There were many more details to it than that, but I think the gist was their study underscored either how important it was to have an ordered approach to interpretation, or that experienced providers just through trial and error over time came up with this method or were trained that way. Interesting questions. I'll have to go back sometime. Way too much quantifying for what seems obvious enough though.

Exploring the Relationship Between Eye Movements and Electrocardiogram Interpretation Accuracy
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5137031/

The painful subject of retention:

The flaw the authors point out: regardless of the approach, the subsequent gains from the teaching followed by immediate tests only supply short term learning in most teaching approaches. **Retention** is the true measure of how effective a student learns and testing *months* after the original learning, ie follow up testing is the BEST test for something if truly internalized.

This seems obvious: when you take a final after 3 months of classes and segmental tests, just the review process and the weight of a permanent grade (the stick) motivates. Not our favorite approach but one we know works. (I'm not a formally trained teacher by the way.) And the authors show the outcomes of tests where this is measured. The authors cite a test which measured a loss of 53 – 60% of what was learned after just 2 - 4 weeks. They point out also after a month or so erosion or the "rate of decay" slope of what was learned flattens out.

Get the connection and get out the stick!

In conclusion the authors evaluate an array of teaching approaches. They offer the integrated approach as one that offers the best classical ECG teaching and – **Number 1 in their appraisal** in successful ECG interpretation education **–** add a 3 dimensional, graphical program like ECGSIM (or something similar) to make sense of and link the abstract ECG tracing to the hearts physiology. That is: understand and internalize / have the ability to visualize the electrical potential winding it's way through the heart's myocardium, it's action, and how it produces the ECG tracing that it does.

[And it seems the authors want students to internalize this connection to the point of **verifying the pathology within cadavers**! - I.e. proving THIS clot, THIS ischemia, THIS myocardial necrosis, and the patients subsequent **death** they (the clot, the ischemia, the necrosis) caused and *the tracing produced on this ECG* ***that you missed*** carry a real weight. The pathologic ECG tracing and **the real clot** within the **cadaver** heart, ie the one in your **dead patient**, are *correlated* . **That's extreme**. (Talk about a stick :-)).

But above all **Number 2** recommendation - using **the summative approach**: yes, you MUST test. And the test must have gravity, weight, a permanent mark (like a permanent grade) and thus must have an impact on the student.

Some quick criticisms

my argument #1... I think if you're a thinking person, and you read ECG's regularly and you feel the clinical weight of the ECG, you come to internalize – through other ECG education and personal academic and physiologic interrogation of ECG tracings -- the 3d and electrical effects of the "**3d spatial electro-cardiography** approach".

Argument #2. A second criticism I have of the authors and their several negative references against rote memorization of ECG tracing by morphology and pathology that it is too abstract. That, in my opinion, is no different that learning to read or interpret an ultrasound or a CT scan or an MRI: all are *anything* but everyday familiar visual images to a new student or practitioner. Nobody "just knows". **Its *all* abstract**. CT's and ultrasounds may be more direct, but **you still have to learn and internalize the images before they make sense**.

(Be it US, MRI, CT, all imaging approaches – any process that links learning to understanding and getting oriented to a cardiac ultrasound, or a chest or abdominal CT, etc. takes time, takes memorization, takes relating of an abnormal version to a "normal" version to make any sense of it. Any novice will be just as lost in the beginning. Think back to your own learning days. In the end though , "anything that works".)

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NOW for something completely different, to something less weighty – the **dancing ECG approach** to ECG interpretation:
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Cardiologist John Grammer, MD, FACC, demonstrates multiple heart rhythms and dysrhythmias. He demonstrates in this hilarious "heart dance". Produced by no less than Bigeminal Productions. By using all four limbs, he shows convincingly what is happening electrically in the heart – right up to the point of "dying". He doesn't die of course.

https://www.youtube.com/results?search_query=ecg interpretation dance
https://www.youtube.com/watch?v=TJR2AfxVHsM

Living Arrhythmias with soundtrack

By what some would call pantomime Dr. Grammer demonstrates:

Normal Sinus Rhythm,
PVC's, PAC's,
First Degree AV Block,
Wenkebach - (Second Degree AV Block with 4:3 Conduction),
Atrial Flutter,
Atrial Fibrillation,
Right Bundle Branch Block,
Left Bundle Branch Block,
Left Anterior Hemiblock,
PVC,

Ventricular Flutter,
Ventricular Fibrillation,
Cardiac Arrest with Defibrillation back to NSR, and lastly,
Unsuccessful Defibrillation.

https://www.youtube.com/results?search_query=ecg interpretation dance

Some highlights: [Isolated PVC's at 1:35 -- pretty hilarious, the bundle branch blocks get funnier yet 4:15 -- successful defibrillation after series of degrading rhythms; from 40 years ago -- watch till end! Right back to the class room.

If you YouTube "**ecg interpretation dance**". You'll also get multiple other examples of similar demonstration. After working through **ECGSIM**, how can you find a better low tech way to physically, kinesthetically, *experientially*, from "the neck down", get a connection to what the above authors called "**spatial electrocardiography"**?

The web site '**Life In The Fast Lane**' adds a few more similar demonstrations:

https://litfl.com/emi-032-living-arrhythmias/

I spent a mall amount of time doing a search that may have actually done a study that shows a benefit interpreting ECGs using doing this sort of kinesthetic approach. There were a list search results (using "**kinesthetic approaches to learning ECG interpretation**" as the query phrase. The article above on the squeezable sponge heart above was culled as well as multiple educational articles stressing the importance of using kinesthetic, visual, and "deep approaches" for other than primarily verbal learners.

I found this title interesting: "**Association of kinesthetic and Read-Write Learner with Deep Approach Learning and Academic Achievement"** used in medical schools and on medical students – interesting at first but excessively full of educational research jargon.

It says to me and underscores **people have different ways of learning**. I'll leave it at that. I found no serious studies in my quick search – which I think demonstrates the bias in education for the verbal rather than nonverbal approaches and the predominance of verbal (meaning from now on "left brained" dominant) educators and researchers. And therefore by its very nature limiting non "left-brain" approaches to learning.

More to come on this.

(I spoke too soon. See **Karen K.Shultz Ph. D. -**-- paper on **Dance and ECG interpretation** – write her and see if her dance demonstrations looked anything like **Dr. Grammers** demonstrations above. They actually **do a test** and found **positive correlation** between doing the dancing and receiving higher scores!

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2720366/

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I actually did writer heard but never heard back – see letter in "further resources"

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Back to the more academic...

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Evaluation of a web-based ECG-interpretation programme for undergraduate medical students [7]

Mikael Nilsson 1, Gunilla Bolinder, Claes Held, Bo-Lennart Johansson, Uno Fors, Jan Ostergren

Affiliations expandPMID: 18430256 PMCID: PMC2394519 DOI: 10.1186/1472-6920-8-25
https://pubmed.ncbi.nlm.nih.gov/18430256/

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This study showing an evaluation of a **web based ECG online program** out of Sweden – published in 2008. (Showing pretty much classical approach to ECGs but **exemplary of good conventional ECG teaching programs**)

The reason for the study – student demand for more training and lack of time for instructors to teach (they don't say this but if they're honest they might add – like every other study program in med school and even in residency – the hesitancy of instructors to teach ECG interpretation is also *secondary to their feeling less than competent at teaching it*. This is cited in numerous papers)

The authors **Nilsson et al**, also like every other paper I've read also point out the gap between the recognized need to be competent in reading ECGs and the demonstrated lack of it and the clinical outcomes / adverse outcomes from the two not squaring.

Methods

The web based program (based on KOLBS **experimental learning –** another pedagogical learning theory) consisted of 4 parts:

5 parts:

1) Intro – anatomy, how the tracing is registered, Einthoven's experiments, the electrical activity of the heart;
2) what the tracing means; the ECG in detail, all its segments; an ECG checklist;
3) pathological ECGs: 25 conditions presented and explained;
4) clinical ECG cases: 70 specially selected "typical" ECGs picked for clinical relevance and presented in a clinician scenario the way a practitioner might engage such a patient complaint;
5) testing

Test setting: test group and control groups – roughly equal sizes (31 and 32 participants respectively), entered on a voluntary basis, log on time measured and counted. Opinion about how students liked the program / how effective they thought it was measured – mostly favorable (about 4.1 out of 5 rating) .

pre-course: in 5th semester (ie in the first half of the third year of the 3 years of Swedish medical school) – 15 hours cardiac instruction given to both groups.

(The control received another 3.5 days conventional cardiac physiology and ECG interpretation training given in 6th semester;

In the actual course period – the 6TH semester. After 5 months of using the **ECG Tolkning** software ("Tolkning" BTW is Swedish for 'interpretation') students diagnostic skills were tested: the actual test and grading done without grader or tester having knowledge of the who was in what group (ie blinded in that sense) .

RESULTS – The test consisted of diagnosis and interpretation and a variety of questions regarding the **eight** different tracings. The online ECG trained group (the test group) showed significantly better results: Test gropup average was 9.7 (SD 2.19) compared with 8.1 (SD 2.47) in the control group (p = 0.03). Maximum points was 16.

Discussion

The authors reiterate the importance of improving ECG reading skills. They also point out **the difficulty of finding both qualified ans willing instructors to teach ECG interpretation**. They also want to increase utilization of resources (like the internet) students can access pretty much anywhere at anytime on multiple devices. They also want to monitor how receptive students are to utilizing such programs. This only seems to make sense. Students can also self quiz and self test through such programs.

Authors were concerned why students chose NOT to use the online program (since the main author was the inventor and developer of the program) – I have a hard time thinking behavioral reasons (ie not liking computers, – maybe more the truth – they'd had *enough* of computers and studying – and maybe that's what the authors meant) --- why only 62% of those who volunteered actually used the program? Or of their medical class only 62% volunteered for the study. According to the authors this is pretty normal: about only 2/3rds of students who volunteer for any study actually show up to participate.

The results support the authors contention that well-performed instruction in pedagogically sound programs can speed up learning, deepen learning, and if done right capture / maintain students interest.

The participating students knew the authors of the test who were also instructors at the school were the makers of the **EKG-Tolkning** and did possibly not want to get on their bad side by not giving glowing reports – but nonetheless the test was successful and showed good results.

criticism: small numbers of students – these were not huge tests; its conceivable the software is too close to the authors and students might feel somewhat burdened to praise their instructors? Its a valid thought. It may have influenced more motivation in students; – students self select who just learn better from computers and are may invite more 'people pleasers. Just conjecture.

Conclusions

Anything helps! With a good program and a motivated student outcomes are promising (this does goes against the larger more recent group findings in the **Breen** "ECG Interpretation Skill Acquisition" paper about self-directed learning above – but this Tolkning paper was **to fill the void where there IS a *lack* of teachers**, small groups or group lectures availability.

How many ECGs to interpret before competency?
Lastly, the authors point out accurately nobody can really demonstrate how many ECGs are needed to become a competent reader. To this point they point out the AHA and the ACC 's arbitrary "500 ECG interpretations" needed to get competent. The authors admit more needs to be known – but think in 2008 – this can help.

So, whats the best way to teach? Still not known...but this can help

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A 3D App for Teaching Nursing Students ECG Rhythm Interpretation

Abby Holthaus Ph.D.and Vivian H, Wright

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After reading this paper 6 or so times and reading certain sections of this paper more than a dozen times it's unclear to me what's the clarifying unique piece of research this represents.

The authors – like so many others – point out the necessity of accurate interpretation of ECGs. Further they point out the necessity of nurses, especially critical care nurses, in direct patient contact caring for monitored patients who are both sickest and thus require nurses attending those patients to be accomplished at recognizing dangerous rhythms in order to save lives. The need is definitely established.

After spending an excessive amount of time reading this paper over and over I realized I was **reading an extended *brief*** – complete with IMRAD format, discussion, etc., and conclusions, and a list of scholarly references in a separate reference section at the end. The paper made no sense to me – of course since I was reading a deceptive looking brief standing in for the real paper (a doctoral dissertation) . At this point – and feeling that this paper I'm writing here the writing of which *must* be accelerated -- the original paper was discovered after a brief internet search at :

https://ir.ua.edu/bitstream/handle/123456789/2171/file_1.pdf?sequence=1&isAllowed=y

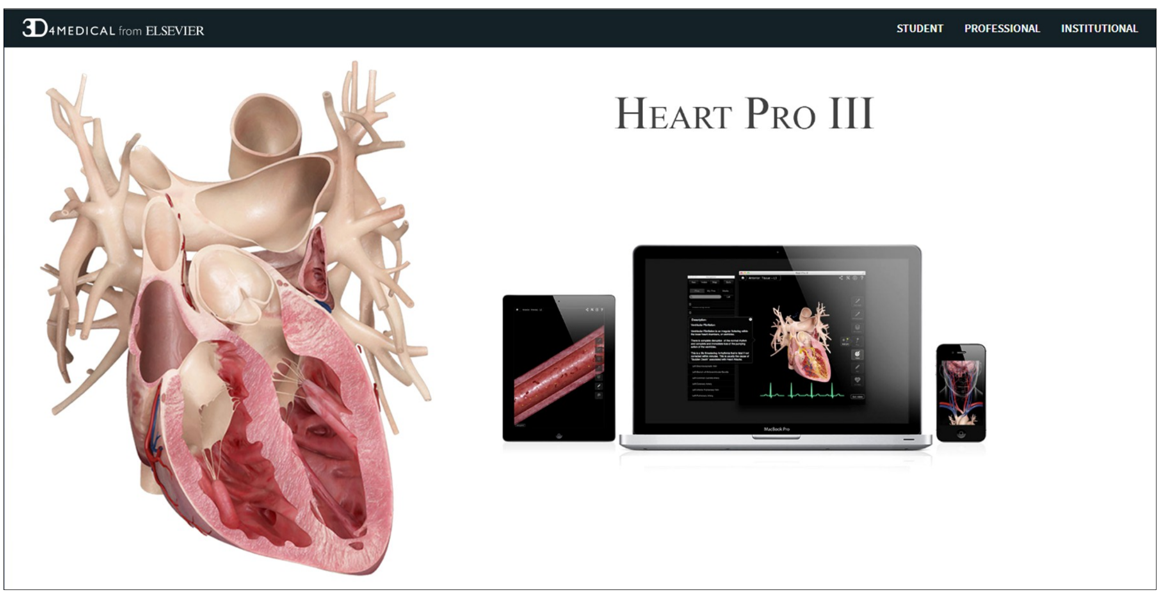

Illustration 3: Heart Pro III App

What is plain in the original paper is the same motivation for the study (accelerating confident and accurate ECG interpretation) but through the lens of a great deal of educational pedagogy. Something I'm picking up as a necessary requirement for writing post graduate research on teaching, well, writing pretty much on anything concerning "graduate education". Looking beyond the pedagogical aspects of the paper the real gist of the paper is the use of 3d apps being incorporated into multiple educational fields – as diverse as aiding in the education of autistic students to learning ECG interpretation in nursing school.

The original paper reveals the actual 3d App used – **the Heart Pro III** (**https://3d4medical.com/apps/heart-pro**) never mentioned in the original (brief) paper I read. The content of what was tested in her study - quoted from the paper:

"The pretest and post test items included identifying ECG interpretation concepts such as blood flow, the conduction system of the heart, dysrhythmias, and three lethal rhythms (ventricular tachycardia, ventricular fibrillation, and asystole) were covered in both learning experiences."

The gist of the study: is there a learning advantage between nursing students using 3d apps as a learning intervention versus nursing students learning ECG interpretation in the conventional classroom lecture fashion? There's plenty of studies showing computer program can aid in learning and at a level commensurate with conventional ECG education. I'm not so convinced or concerned there's any real major difference but I didn't study this, and the authors did. And *that* was the purpose of the paper – since there has been no research on the contribution of iPhone apps to learning.

The authors were also examining the "app question" through the pedagogical teaching theories of Gagne, Briggs and Wagner's 1992 "Nine events of Instructional Construction". This part is beyond the scope of what I'll pursue in this paper.

So, **are iPhone apps better than conventional ECG interpretation classroom teaching?** The short answer: **no**. Nothing superior – ***but*** in her study they were found to be **just as good**. Pretest scores were similar in both the experimental group and in control group. Post test scores in both groups showed significantly better scores than the pretests – and at equal rates of improvement. Progress. I'll leave it at that.

Final note on **Heart Pro III**: after looking at a half dozen or so YouTube.com manufacturers and personal user descriptions and demos, there is **nothing** in this app that I can find **that connects** the excellent 3D cardiac anatomy illustrations, nerve conduction anatomy, procedural demonstrations, and videos ---- **with ECGs**. I found this rather astounding. Especially after all the verbiage about how nurses need to know how to interpret *ECGs*.

This at best is only a partial and incomplete solution. Reverse engineering the study I can only guess the authors intention is promoting a better understanding of heart physiology will increase accuracy of ECG interpretation. But I don't want to put words in their mouths.

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6-step method compared to pattern recognition taught in Europe

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Authors here want to challenge the usual European approach of pattern recognition versus the SSM or "Six Step Method" taught in Advanced Life Support classes in Europe

Per usual in every paper is the conflict between the amount of time needed to teach rhythm recognition the importance of knowing how to recognize the most common dangerous rhythms, the limited time given to teaching (secondary to all the competing concerns) and the overall general sorry state of ECG interpretation skills early on in a medical or nursing career – if ever accomplished.

First question I have is **what exactly the SSM** or the "**Six Stage Method**"? It's not explained in the paper. Here is a search result that describes it as:

1.) Rate and rhythm
2.) Axis determination
3.) QRS duration (Intervals)
4.) Morphology
5.) STEMI mimics
6.) STEMI (Ischemia, Injury, Infarct)

Link here:

http://ems12lead.com/2010/01/25/the-six-step-method-for-12-lead-ecg-interpretation/#gref

This is is pretty close to a **6 step method** I have learned over the years as taught by **Dr. Amal Mattu** roughly: **1)** rate, **2)** rhythm, **3)** axis, **4)** intervals, **5)** ST elevation / depression, **6)** overall morphology gestalts, **7)** outliers (eg Brugadas, ARVC, Crochetage patterns, etc.).

Another ~ 6 step method outlined here from a PDF out of Poland here: **EJTCM_2018_1_1_Kozlowski.pdf**

found here: https://depot.ceon.pl/handle/123456789/17208

step 1) baseline **rhythm** or rhythms;
step 2) The electric **axis** of the heart should be analyzed;
step 3) The next step is the analysis of all **supraventricular and ventricular conduction** disorders (I.e. intervals – JOK note) ,
Step 4) In the next step, the structure of the heart chambers should be assessed in terms of **enlargement** and **hypertrophy**;
Step 5) analyzes all that is associated with ischemic heart disease, myocardial infarction and previous coronary events;
Step 6) describes **tachyarrhythmias**;
Step 7) describe the **pacemaker** and implantable cardioverter-defibrillator tracings

YET, Another 6 – Step Systematic approach:

09: Cardiac Investigations: Electrocardiography

Applying the 6 step approach

The following section will allow you to apply this approach to analysing common arrhythmias.

This will include:

- sinus rhythms
- atrial arrhythmias
- ventricular arrhythmias
- conduction abnormalities

If you want to remind yourself of the 6 step approach you may want to revise the following rhythms.

The 6 stage approach in practice

Study the rhythm and answer each of the questions below. Select the next button to examine further rhythms.

1. Is there any 'co-ordinated' electrical activity?		Yes ☐	No ☐	
2. What is the ventricular (QRS rate)?	<60 ☐	60-100 ☐		>100 ☐
3. Are the QRS complexes regular or irregular?		Regular ☐	Irregular ☐	
4. Is the QRS width normal or prolonged?		Normal ☐	Prolonged ☐	
5. Is atrial activity present?		Yes ☐	No ☐	
5a. Is the atrial activity...	P waves ☐	Flutter ☐	Fibrillation ☐	N/A ☐
6. Is the atrial activity related to ventricular activity?	Yes ☐		No ☐	N/A ☐

From Heartelearning.org – permissions pending

This above is a screen shot from a European-generated, multi-country reference site that has a link to the European Society of Cardiology – **Heartelearning.org**:

https://www.heartelearning.org/labyrinths?id=47890&parent=47895&sessID=1

and **https://www.heartelearning.org/about**

Again, all pretty similar – though in slightly different order – and not much about ST elevation or depression. What my teacher Dr. Amal Mattu always stresses is not that any particular order is better than another but whatever method you have you ***do it consistently*** (i.e. in the same order, same questions on every ECG you evaluate) . For further exploration – the European ALS site (an equivalent ACLS in the states) : **https://www.erc.edu/courses/advanced-life-support**

So that's an idea of what the **Six Stage Method** most likely looks like. Now, what might the traditional descriptive method referenced in this paper look like?

What can be deciphered about the European descriptive teaching method in ECG recognition?

More the pedagogical question: descriptive versus the six step question -- something I'm learning as I do this paper: "teaching has a whole other aspect to it -- the academic side. There are 3 links / references given In the text and footnotes and I did an internet search using the links and footnotes.

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The effectiveness of nurses' ability to interpret basic electrocardiogram strips accurately using different learning modalities

LeeAnna Spiva 1 et al
https://pubmed.ncbi.nlm.nih.gov/21985075/

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From this this publication: *"Historically, the instructional **method of choice** has been **traditional lecture** or face-to-face education; however, changes in the health care environment, including resource constraints, have necessitated examination of this practice."*

This is from footnote #9, (several links will not load). From my own search I'm discovering the "**descriptive teaching method**" is a defined pedagogical approach used in all sorts of different aspects of education meaning essentially using the words, nouns, adjectives, etc. common to the situation / profession / body of work (in this case cardiology and ECGs) that are used within that specific profession.

In our immediate case it means learning terms common to reading ECG's like "intervals, p-waves, grids, sinus rhythm, tachycardia, bradycardia, asystole, PEA, electrical conduction, etc.); And learning to associate the visual partners described by the language. (We're going down an abstract wormhole here.) **How different in the end this was from the Six Step Method?** I don't know and will not pursue this. Suffice it to say they're different enough to the authors to get the funding to pursue the test.

The Results:

Further, suffice it to say the authors showed with p-values, and T-tests, a randomly controlled trial with about 200 students with the usual fallout and no shows, isolating for as many other variables as possible, etc., the SSM group (**group A**) was very close in proving an as efficacious approach as the descriptive method **Group B**) --not of a statistically significant amount but still **slightly lower** scores *on the immediate test* after the classroom teaching (the "intervention"). BUT, **more importantly** as the question of "**retention**" comes up again, in an unannounced *follow up test one month after* the original teaching sessions, showed statistically significantly *better scores* in the A-group: i.e. the group using the **SSM method**. Thus proving, or at least it looking like the **Six Step Method is easier to recall and sticks in the brain longer** than the descriptive approach.

So the authors highest hope is this results in less missed diagnoses or fewer miss-diagnosed critical ECGs and thus better outcomes, and fewer bad outcomes etc. We can only hope.

The 10 rhythms studied:

Ventricular tachycardia
Ventricular fibrillation
Sinus bradycardia
Sinus rhythm
Atrioventricular block 3rd degree

Atrial fibrillation
Supraventricular tachycardia
Sinus tachycardia
Asystole
Atrioventricular block 2nd degree

Students' rhythm interpretation scores at initial and final assessments

(one month after initial)

All students (N = 134)

Group A (N = 73); SSM		
Score (initial)	8.71 (1.285)	6–10
Score (final)	**8.25 (1.460)**	4–10
Difference in score	−0.47 (1.395)	−5 to 4

Group B (N = 61); Descriptive		
Score (initial)	8.74 (1.303)	3–10
Score (final)	**7.84 (1.440)**	4–10
Difference in score	−0.90 (1.350)	−4 to 2

ttps://nursinganswers.net/essays/study-on-teaching-the-electrocardiography-procedure-nursing-essay.php

In the US: https://www.ahajournals.org/doi/10.1161/circulationaha.106.180200

The link just above is also a pretty nice summation of ECG rhythms too.

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Teaching Crucial Skills: An electrocardiogram teaching module

for medical students [9]

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Going to start speeding it up considerably here. In this study, as usual, to answer the now obvious observation medical school students, PA students, nursing students, residents - even fellows - in the end stages of their residency – lack confidence and accuracy in ECG interpretation. **Dr. Samuel Chudgar et al's** approach to this conundrum: build a program: an accessible (anywhere, anytime) program students can repeat access and study as needed as often as needed.

This group recognizes as much as can be learned in the traditional medical school lecture programs taught by accomplished cardiologists reviewing and interpreting multiple ECGs and scenarios – this isn't enough. With the addition of smaller follow-up group workshop reviews lead by cardiology faculty that are both interactive and highly rated by students – again, results fall short.

Dr Chudgar et al also recognize some things I've not seen mentioned in before: **1)** the recognition students have *varied learning styles*, **2)** self directed schooling and studies – given YouTube.com, the internet, all the data devices available – more than ever there are *opportunities to exploit*; and **3)** *repetition* seems to be a key in ECG mastery. With all its variations and complexity you have to see lots of ECGs often before they start to 'sink in', before you develop confidence.

What they did

Rather than duplicate every ECG pathology (eg like the 94 different rhythms recognized by the ABIM (see below in **Appendix**), they would construct a teaching program built around **75 total instances ECGs** comprised of **15 highly encountered pathologies** in Internal medicine, packed it all into a very accessible, portable computer program.

In developing their program, each rhythm was contextualized within a clinical scenario, each rhythm had a highly detailed reproduction of the representative rhythm – which the student then tries to interpret. Each rhythm had it's own "set up" page with a second corresponding "answer" page. Images were of a very high quality. Answers were pointed, highly relevant, and linked to other related rhythm pages.

Students were prompted to **look for rate, rhythm, axis, intervals** (not unlike the Six-Step Method seen just above) **and an overall interpretation**. A second page with all the answers, with the interpretation and case specific details immediately followed the initial "challenge" page. In later updates links to other ECGs with the same diagnosis or clinical scenario were made a available. [Many of the updates were driven by student enthusiasm and suggestions – even actual link-coding within the module performed by "a tech savvy participating medical student".]

Implementation

A main objective the authors had was ***accessibility***: students could download this to personal computers, to their clinical computers where they could access ECGTM while actually confronted with a similar real world clinical situation. They could study on or off campus, with or without internet access – in a word if they had a computer or mobile device, this module was accessible. The module was distributed to students in their second year at the beginning of their eight week internal medicine rotation (clerkship).

All participating students received prompts and reminders through emails and other announcements at different timed intervals reminding them ECGTM was there for them and of quiz dates. The authors concede there is noting really novel about their program other than it's accessibility.

These are the 15 rhythms included in the module:

Normal sinus rhythm
Sinus bradycardia
Sinus tachycardia
Sinus arrhythmia
First degree atrioventricular block
Second degree atrioventricular block
Complete heart block
Myocardial ischemia
ST-elevation myocardial infarction
Hyperkalemia
Left bundle branch block
Right bundle branch block
Atrial fibrillation8 & Atrial flutter
Paroxysmal supraventricular tachycardia
Ventricular tachycardia

How well did ECGTM work?

The authors set up a **pretest**, at the beginning of the IM clerkship, a **post test** (both covering the same rhythms and materiel) and an **end of year test** where students could use module for studying. Again, high in the authors theory about learning ECG interpretation was **repetition**. And repetition being the key to mastery – pursued as self-directed study.

Adjusting for MCAT scores and cumulative grading within other med school class performance they proved a significant increase of scores over classes whom only took the conventional (but again highly popular) lecture classes given by cardiologists.

The study goes on to state many students requested the module even be available during their residency year (to the delight I'm sure of the authors – what greater affirmation can you get than improved scores *and* requests for yet more access from graduates?)

Breaking down the results

The authors concede there most likely was a “cram” factor: ie students knowing the e.g the end of rotation test or end of year test was coming they could easily review the material. So even though scores were significantly better than students who did not have access to ECGTM the authors could *not* really say the module was a *causative* factor in **retention** or if just the weight of a looming test driving them to study for it (ie 'cram') lent itself to the better scores.

Of the 101 students who had access to ECGT 54% used at least ½ of the module, 98% who used the module said it was helpful, 66% reported using 2/3rds of the cases, 36% said by years end they studied the entire module.

The scores: post-clerkship compared to **pre**-clerkship scores: **median score *70%*** with a range = *60 – 80% correct* compared to **median 57.5%** with a r*ange of 40 – 60%*, p < 0.0001 in the pre-exam respectively;

End of year exam: **median = 92%** with a range of 80 – 96%.

Students from the previous year (who did not have ECGTM) scored median **76%** with a range 68-84%.

To add some sort of “secondary control” the authors **compared laboratory exam scores** from the IM clerkship from the same two years and found scores form **both years at 85%.** This suggests the ECGTM group was no smarter than the year without ECGTM. (That's how I interpret the authors comparison anyway.)

Confidence is a subjective finding but increased confidence was reported by the majority of students.

In conclusion

The authors note in closing several things: **1)** they cannot prove causation **2)** they cannot really say how much students really studied or how much they may have learned from other sources since all study efforts were self-reported and no other reporting measure was recorded, **3)** opposed to other studies where self study or self-directed studies (SDL) were shown to be inferior to "*summative**" models, their study showed self directed study was fruitful. **4) ECGTM worked**.

**Summative* models are those in which the weight of an influential exam will be looming and is a large driver of higher score outcomes. (From what I'm gathering this a 2 sided camp between educators: "carrot or stick" education.)

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How can we improve teaching of ECG interpretation skills? - and the idea of retention

Ruapach et al (2016)

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T. **Raupach** et al asks again how ECG interpretation ought to be taught. His major areas of interest in this study concern to what effect how do different kinds of approaches impact **retention**. And are single teaching interventions enough? (ie are modules – single teaching interventions - taught during one clinical rotation enough to last through to residency).

He recognizes the different kinds of non-traditional teaching programs tht have been atempted (e.g like those mentioned above – the kinesthetic approaches, 3D Spatial Electrocardiography, etc). But most of all he wanted to explore if an intervention had lasting consequences and might the permanent consequences of that intervention, like an exam score that went on your permanent record might motivate you more than just getting kindly feedback ("kindly feedback" is my characterization) This is pedagogically termed a **summative** evaluation. Versus a **formative** exam (where you get the kindly feedback) on your progress but no final grade, no looming final exam.

It was his further hypotheses the summative exam would have more impact upon **retention**. Raupach's approach concentrated again on the more traditional approaches to ECG presentation. Involving nearly 500 students Raupach divided up his groups into each of the three teaching methodologies. Then each of the these three groups were divided in 2 types of evaluation.

The evaluation in each division was divided between summative and formative. He tested **3 teaching methods** in his words "**intensities**" in least intense to most intense order :

1) self directed learning (SDL);
2) traditional lectures;
3) and peer-teaching (regarded as the most intense).

Study design

All interventions took place over a six week cardio-respiratory module at Gottingen Medical School, in the fourth year of study. The **lecture** groups and **peer teaching** groups either had eight evenly spaced lectures or eight small group meetings; the **SDL** group had all the same material reproduced in self-study materials. All three groups received equivalent baseline introductory teaching (over three lectures) before splitting off. All groups were random in assignment.

All three groups received **evaluations** at three different times: an **entry** exam, an **end of module** / **final** exam (EOM) and then a **retention test** two months after the conclusion of the 6 week cardio-respiratory module. A two month interval after conclusion of the six week course was considered by the authors to be a **medium-term** assessment of retention. (6 -12 months generally being long term)

The tracings

Forty ECGs were studied in all three test groups organized into different related sections: stable coronary artery disease, acute myocardial infarction, ventricular hypertrophy, bundle branch blocks, bradycardias, tachycardias, and miscellaneous tracings.

*Very **interestingly** all tracings were given **without** clinical context (very much unlike all previously studied approaches)

Tracings in the **entry exam**: normal ECG, a first degree AV block with right bundle branch block and a STEMI. (this is directly form the paper – possibly a typo? Might they mean first degree AV block eg with a long PR interval *and* a RBB?) Tracings in the **EOM / Final exam**: Mobitz type II AV block, STEMI, atrial fibrillation, left ventricular hypertrophy; and QT prolongation. Tracings used in the **retention test**: tachyarrhythmia with LBBB, and acute right heart strain.

All students were graded on descriptive use of rate, rhythm, axis, interval, signs of hypertrophy, and ST segment abnormalities. (this much like the **six step approach** above) ;

Listing **rhythms** for easy scanning when comparing to prior studies above:

normal ECG,
first degree AV block
right bundle branch block
STEMI
Mobitz type II AV block
atrial fibrillation
left ventricular hypertrophy
QTc prolongation

The results

As might be expected, all three teaching approaches lead to learning (I'm not being sarcastic here :-). However the peer teaching and lecture approaches produced results ahead of the SDL approaches.

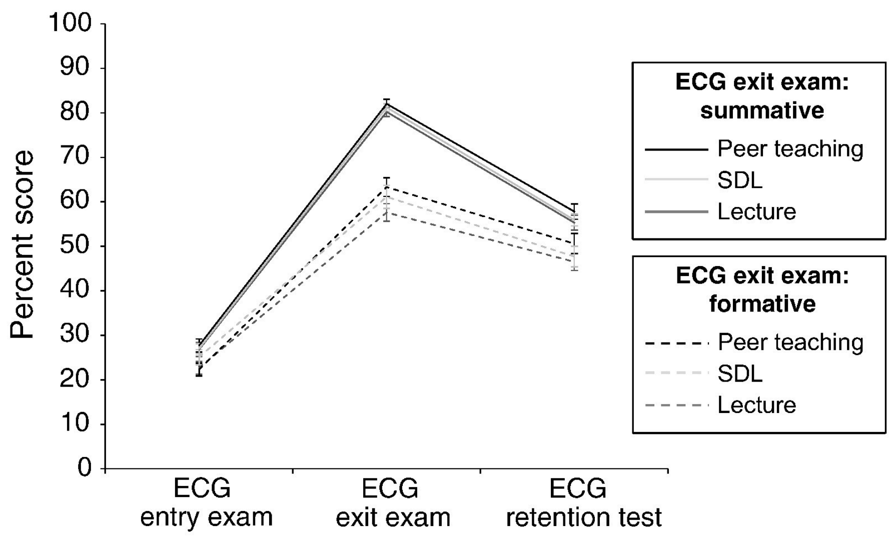
Overall test scores in entry, exit and retention exams were **25.6%** plus or minus 13.2 % (for entry), then **72.9%** plus or minus 17 % (for the final exam) and lastly the retention exam produce a mean of **53.1 %** plus or minus16.8 %.

The **summative** exam as expected – **the stick** in the stick and carrot approach of exams – produced a mean of over 80% scores, the **highest in the peer-teaching group**. The **Formative** evaluation group (the carrot group) had the lowest scores in all three evaluations.

Where were the biggest losses on the retention exam 2 months later?

What I found unexpected – and maybe this was the authors intention -- the **peer taught summative** approach group (the highest intensity, biggest stick approach) also **showed the largest drops** in retention test scores. In my opinion it seems the harder you cram, knowing the this grade is permanent, feeling the most pressure, the better you do – but the harder you fall afterwards. Said a little differently, **the more you stuff in your brain, the more stuff leaks out**.

Reproducing the student performance graph puts this into a little more perspective:



Raupach, et al conclusions

The authors conclude, among multiple conclusions, yes, you study harder and do better on tests with a **big stick** over your head, ***and*** do better yet with more intense study situations. But without repetition of the material, you forget more too.

I would also add, in comparison to other studies above, this the first study I've seen where the ECGs were not presented within a clinical context – at least in the reference materials. In their words:

"tracings in the written guide were not accompanied by information on the clinical context in order to avoid cueing effects".

I do not know what cueing effects are (I looked it up but there was a lot of statistical jargon). I won't pursue any further. I'll trust the authors in their pursuit of the purest sort of data and the most defensible test know what they're talking about.

One last thought on this study

The authors talk a lot about "**intensity**" of the learning situation. Peer group being the highest intensity, lecture group next highest and self-directed study the least intense. My own anecdotal observations (and observations of other clinicians as well) and ***the most intense situation*** is where you can potentially learn the most, and that's in the actual *clinical situation where you have the most to lose. O*r more accurately where the patient has the most to lose. I'm thinking here of clinical misses, codes gone awry or poorly, patient deaths, even - but hopefully never - malpractice.

Experience equates to the result of all those harrowing clinical situations and *bad* outcomes. And those bad outcomes at least in my experience drive the most intense learning (and usually the most self directed learning) and thus lead to the most retention of material and the best kinds of clinicians. Usually. Experience that lasts is hard won / hard bought.

An earlier paper by Raupach Et al in 2013 [11]

I will note at this time Raupach et al completed a nearly exactly **similar test in 2013**. They discovered **nearly exactly the same results**. Not as clear in the 2016 test above, the authors noted summative test participants actually average over **2 hours per week extra ECG study time**. This was as much or more time spent than the SDL group (self directed learning) . The authors were also clearer and more focused in the 2013 paper in pointing out the explosion of alternative and novel teaching approaches and methods.

Criticisms against novel approaches
Part of the criticisms Raupach voiced were against all the claims of breakthrough results in breakthrough formats – but whose claimed **"breakthrough" results were never tested**. His contention was that all these new novel approaches were tech and resource intensive, thus costly, and again no sure proof they offered any true advantage to "old school" classroom lectures. (In my mind this is not unlike the battle between traditional fire and brimstone religion and "New Agey" types of, err, spirituality, for lack of a better word)

Strength of the summative approach
Another hypotheses that drives Raupach was his contention it ***doesn't matter what the method you use*** – If there's a true **impact involved**. A final exam that has **consequences** in the form of a permanent grade that was *recorded* that e.g. a future residency board may look at and say "nope sorry, your tests scores just don't cut it" will drive learning more than the friendly 'steering' found in the formative approach.

The question of *retention* left hanging
Raupach's **results** here matched almost precisely the the results in the **2016 test** (above) – but he had one nagging question: he had no idea how much these more intense, result driven, summative approaches affected **retention**. Thus **the driving motivation** for the 2016 test above. To paraphrase again the **2016 result**: "the more you force in, the faster it leaks out".

[I have to add lastly paraphrasing like this might not be adequate since what Raupach showed in both tests was formative testing *never reached* the exam scores attained *by any* of the summative approaches, in fact the 2 month summative retention test scores were still very close to the best scores attained at the formative end-of-module scores.]

One more article on retention, then an apparent game changer before we get to the meat of this paper:

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Acquisition and retention of ECG interpretation skills - after a web based ECG tutorial[12]

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In this paper Signe Rolskov Bojsen et al, in my view wanted to shore up a few blind spots in the Raupach study idea just above mainly regarding retention. Before going into this suffice it to say these last 3 papers on education and testing hardly seem anymore than underscoring common sense. But I suppose in this age of trying to squeeze out as much as we can for as little as we can – *and quantify it as you do it* – suffices for research, or knowledge of some such thing. In the name of completeness I include it. Briefly.

I should also add **Bojsen** also wanted to compare **web-based interventions** against traditional teaching interventions. Of primary importance the team also wanted to figure out how long students hung on to newly taught material – ie the notion of **retention**. (Similar ro Raupach above). Different than Raupach, rather than just a one-time retention testing test, Bojsen **tested retention** on three different occasions after a post test: at intervals of **2 - 4 weeks**, then **10 – 12 weeks**, then **18 - 20 weeks**.

The original intervention was a **5 hour intense web based class** studied under controlled conditions. The 5 hours was broken up between a pre-test, the actual teaching (3.5 hours); a break, and a post test. The study involved about 200 students. Students were picked by interest in cardiology (*preferably* with an interest) and filled out to recruit a number of entrants significant enough to achieve at least some kind of statistical power, with any 3rd or 4th yer medical student who wanted to try the teaching intervention.

Students were also screened for the number of ECGs they had interpreted, for any extra cardiology or physiology rotations or classes they may have had and weighted accordingly.

Study material

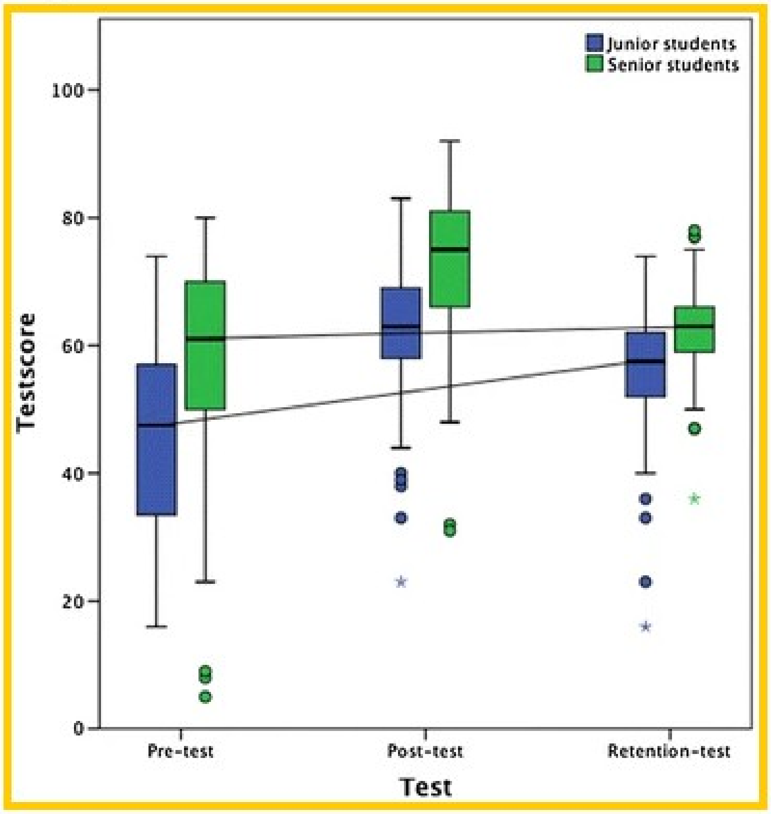
ECGs and **study material** were based on very similar ECG abnormalities we've seen in many similar studies; 15 total ECGs: sinus rhythm, different arrhythmias, heart blocks, bundle Branch blocks, hypertrophy patterns, heart axis, low voltage, ischemia, and clinical scenarios and some repeat physiology appropriate to the summaries of each rhythm.

The **test questions** revolved around rhythm, PR-interval, QRS-interval, QRS-complex, hypertrophy patterns, heart axis, low voltage, ST elevation and depression, T-waves, and Q-waves. Test questions had distractors and in some cases up to 23 options where the correct answer or answer were to be to be gleaned.

Quantified discoveries:

- All groups approximately **doubled** their **pre-test** scores in the **post test** (pre-test was taken right at the beginning of the 5 hour class; post-test was at the end of the entire days web based teaching “intervention”);
- 4th year students scored significantly higher than third year students on the same day **post-test;**
- 3rd year students learned more (based on the larger difference between **pre-test** and **post-test**);
- the most **loss of retained learning** occurred in the first week to two weeks (as was shown in other similar retention type tests in different fields of study);

- Proven here also: half of all **learning evaporated** in the first 2 weeks after intervention;
- little extra loss of learning occurred over the next 10 -12 weeks nor in 18 – 20 weeks;
- the authors also cited another study [13], [14] that showed if learning, study time, and practice time – any or all – are distributed over longer periods, in multiple periods, broken into multiple but shorter periods, etc,. retained learning was enhanced. (I.e. the "**spacing effect**" versus as in this test: "**the bolus effect**"),



From Bojsen, permission pending – very similar to Raupach above

Any carrot or stick?
There was no mention of the "weightiness" of the exam – would it result in a permanent grade, was there a money incentive? Would they graduate out of medical school (the same way if cardiology fellows *would not* graduate from their fellowships as we saw in the 2 part ECG interpretation board exams in the very first article at the beginning of this paper? How much "stick" might be suffered? You can imagine scores may have been proportionality improved. I'm referring here to the effects of a **summative test** hovering over the participants heads.

In conclusion – and time for some common sense

Here's what I gather form this study (and the 2 just before this): and secondarily from an outside study [13]: The more you *stuff* **S - L - O - W - L - Y** into your brain, the **more** it **stays**. The more you cram in **rapidly**, the more rapidly you lose it. The old adage **Practice makes perfect** is **true**. Lastly – and with many applications **use it or lose** it is the law of the land. How long have those bromides / cliches been around - and why? Because they're pretty much true.

Lastly, forms of education may have changed (high-tech, on-line, computer, 3D graphics, movies accessible to all, YouTube.com tutorials, etc, etc, etc,) but the human animal absorbing it all has not changed.

[Again I suspect **the motivation** for these *Raupach* studies and the *Bojsen* study have to do with acquiring funding for their projects and I believe comes legitimately out of a desire to graduate skilled and confident clinicians. There is no faulting of that. And maybe it was just publish or perish, I won't second guess their motives.]

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OK! Now we're into it: finally getting to trigger of this paper

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From China...

Ok, now we're turning to something different – and directly in line with what I proposed 6 months ago – in fact when I stumbled upon this paper around the 4th of July 2020, I had essentially, said "I have 18 papers. Enough is enough. I'll give one last look for something different" – that's when I stumbled upon this paper from China: **ZENG et al.**

[In fact at first I was threatened thinking "they stole my idea" [sic] but after reading it I calmed down :-).] They head exactly in a direction I've thought about for 15, 18, 20 *years* or more. In fact the approach I'm about to propose would probably work additionally *even better* for learning to read Xrays, CT's, Ultrasounds, even "driving" a colonoscope, or experiencing the three dimensional **gestalt** of a child with RSV in respiratory distress – in fact any kind of imaging and imaging interpretation – normal or pathologic, two dimensional or even three dimensional. But hold that thought right there. I'm getting ahead of myself...

In this paper [15] ***"New ideas for teaching electrocardiogram interpretation and improving classroom teaching content",*** Rui Zeng **et al** introduce the idea of the **"graphics-sequence memory method"**.

The idea – which I'll explain in a second - - came out of both instructor and student dissatisfaction if not outright exasperation and discouragement learning *and* teaching ECGs. In China (as stated earlier this paper and study come out of China) ECG interpretation is taught in the 3rd year of medical school. Internal medicine, surgery, and real clinical situations that might rely on diagnostics *like* the ECG, xray, labs, ultrasound etc, are introduced in the 4th year. ECGs when first encountered are abstract, exotic, seem connected to nothing, are seemingly cryptic (well they *are* cryptic at first exposure) and complex.

Without a clinical connection the traditional teaching of the ECG learning module in the 3rd was dismissed or easily let go, forgotten, etc. So when students - now in their 4th year – came into clinical medicine and were expected to be able to incorporate ECG interpretation (since "they had the class - they should already know it") they were at a loss. And so the story of poor ECG interpretation skills, poorly or under diagnosed emergency conditions and bad outcomes repeats itself again in another part of the world, in another culture, and in another language.

Out of this frustrating milieu, the “inventors” of this approach, well, they invented and developed the “**graphics-sequence memory method**”. (I'll just abbreviate this now as “**GSMM**”.)

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What is that? (ie the “**graphics-sequence memory method**”” **GSMM**)

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A brief summary of this method, the **GSMM**: **1)** you break apart a picture – i.e. the *graphic*, idealized representation of a normal ECG from one specific lead or several specific *key* leads. You get a good feel for it. (what the heck does *that* mean – 'get a good feel for it'? Will demonstrate soon.)

Then **2)** you now go down your *sequenced* list of analytic parameters: the usual rate, rhythm, axis, intervals, morphology etc. and **3)** you do this repetitiously starting with **20 of the most common ECGs** in emergency and internal medicine that collectively are missed and can cause bad if not catastrophic outcomes if missed.

You don't need any prior knowledge of the disease or the disease state. What you do have is a method to **visually ascertain** (my characterization) what a normal ECG looks like and *can now say how a pathologic ECG differs from the normal.* And this is accomplished without necessarily knowing what disease or emergency state it represents.

The traditional method in Chinese medical schools (and very similarly to how ECGs are taught world wide) is built around the presentation of eg cardiac physiology along with a **clinical condition** and then coupled to most common kind of heart tracing, i.e. the ECG generated by that condition. You memorize it by rote. Or keep your Ferris Internal Medicine handbook “right there” all the time. Thus the traditional method is disease-based. **GSMM** doesn't sound too revolutionary but compared to the conventional, traditional methods it seems to be.

Especially when you look at the results reported by Zeng.

Audacious results

What the **authors discovered** and **tested** with 200 students (RCT with 100 students in each arm), that when the students after completing the **GSMM** program got around to their 4th year, when they got their clinical teaching, they did considerably better.

One especially striking group result they published were comparing these two parameters:

1) **time needed** to make the interpretation and then, and *so* importantly
2) the **accuracy** of the interpretation

The students were tested in their final semester (assuming 4th year final exam since they do not say in the text) , needing to interpret 20 ECGs from real clinical cases. **The findings:** average ECG time needed to interpret for the **traditionally-taught group** was *32 minutes* and for the **GSMM** group: *18 minutes*. (That alone is more than impressive.)

The clincher for me were the **accuracy rates**. For the **traditional group: 43 %** (which is actually better than flipping a coin since there were more than 2 answers as options – I'm guessing this since I've never seen an ECG test that was predominantly two option answers - you'd expect a closer to 50% rate if that was the case - ie the flip-of-a-coin probability test.)

So **the clincher**: for the **GSMM** group: **accuracy rate was 77%.** Almost *double* the accuracy in almost *half* the time. Pretty phenomenal. Kunj Patel al **[16],** posted similar enthusiasm (but I've not seen their actual test scores) in trying to duplicate and incorporating the **GSMM** approach at their schools.

How the heck do they do it?

I'm going to get into this in a little more depth below in the part which leads to a proposal for study and the core of this paper. For now suffice it to say what Zeng et al stumble onto and all the other studies – or at least in the actual mechanical evaluations of each ECG/ Every learning approach stumbles into - involves a graphic: the ECG tracing. Obvious enough. What no one anywhere above acknowledges – until Zeng – is that the ECG *is* graphical. It's *a picture. More specifically its a line **drawing**.*

And no one else in these medical studies or university / medical school "interventions" seem to recognize or possibly doesn't even know: ***evaluating a picture is a literally different brain function than is a rational or purely linear thinking approach.*** This is my proposal. I'll leave it at that for now.

Interestingly **Zeng** also proposes a **multidisciplinary approach** to learning e.g. ECGs – as unconventional even as telling *stories* about different rhythms.

E.g she offers as an example of considering the relationship between a **P** wave and a **QRS** complex like a couple. Literally as a *relationship **– like "boyfriend – girlfriend"*** relationship***.*** When life is good between P and QRS there's a 1 to 1 correspondence and the heart beats rhythmically, regularly and smoothly. Things are good. If P and QRS are estranged, there's a widening distance between them (like in a type I block). If things are more strained in increasing degrees, you might get a second degree heart block, Mobitz I (Wenckebach). If things go passive-aggressive, now we're in the more dangerous second degree Heart block Mobitz type II – things could sour fast. And lastly, if **P** and **QRS** aren't even talking: this a third degree block.

Seems silly but advertisers know this: if you can give any little thing that registers with an audience, or a buyer, or a client, *if it sticks in their brain*, logical or not, **they'll recall it more easily**. This ironically is scientifically proven. And **isn't that the point?** So there's more to the multidisciplinary approach – which here to me means non traditional, outside pure rational, beyond logical approaches of Western teaching and learning.

[L**ast notes on Zeng et al** actually did a further study [17] where they squeezed out even better results by doing **1)** allowing more access to the teaching module by making it web based and thus accessible from anywhere, **2)** they applied an approach called the "**flipped classroom**" in the sense that rather than an instructor or 'authoritarian' / authoritative professor at the front of the lecture room they *flipped* the norm where the students now **directed their own studying**, at their own pace through the online lessons and *referred to the instructor* for guidance as needed. In essence, the students were in charge of their own learning. **Hence the *flipped* model.** Obviously lots of implications where accessibility to online classes during this age of COVID where distant computer learning isn't just mushrooming, its exploding.

Next to last, **3)** renewed emphasis on **repetition** over a period of time (like from 3rd year through the end of the 4th yielded even better grades and more lasting learning. Lastly, **4)** adding a weighted test – i.e. a test that would count, a permanent grade was added to the sequence: ie **a summative test**. The good old stick. Yes, scores nudged up a yet a little more.]

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Results and Discussion: Part I

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The Secondary Data Analysis approach: throwing a net out there – whew. That bordered on ridiculous.

- Rapid review of what we've looked at in no particular order:

- small group, peer- to peer- study, lectures – formats: which is better;
- **College of Cardiology recommendations**: 2 paths: raw memorization: the 94 rhythms and secondly the 37 clinical scenarios ...
- large variation in **time spent** learning and teaching ECG interpretation;
- a "**moral approach**": **ECG as an Entrustable Professional Activity** – the 13 professional skills: if you say you can do this, then you better be able to do it;
- new web approaches: spatial 3D animation, vector approaches, visual explanation like an animated text book;
- **portability** - a benefit of technology: all the web approaches;
- **kinesthetic approaches** : like the ECG dance the actual rhythm (**Dr Grammer**) to actual improvised possibly connected to nothing, dancing for the sake of dancing kinds of dance led by a teacher – just purely intuitive and probably interesting – if you can relax enough in front of your classmates;
- the **pedagogic concerns** of how to cram everything that has to be taught in to a measurable and calendarized schedule to satisfy academic demands;
- **formative** and **summative**: the weight of consequence: from simple evaluative nudges to permanence record to full autopsy where you see and feel the weight of and actual dead body 2/2 a misdiagnosed ECG – yikes! ;
- **How to test?**
- The question of **retention;**
- Sheer **quantity**: 16,000 or 500 ecgs, or 34,000 to 21: how many to get good?
- The **"six step" methods** and similar approaches;
- Competition for traditional ECG teaching: the **seductiveness** of new **hi tech** modes: US, CT, MRI;
- and lastly the injection of once and for all breaking down the ***graphic*** of an ECG – contrastive and non contrastive approaches;
- **traditional** ECG clinical teaching versus learning the ECG;
- **my thesis**: DRSB drawing skills:

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Results and discussion Part II:

the meat of my proposal and this discussion

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So as we've seen there's lots of approaches to teaching ECG interpretation. What Zeng [15] nudges into in the "**graphics-sequence memory method**" (**GSMM**) is this – and I'm going to just lay it out here now *and* will explain in depth in a moment – is a skill Dr Betty Edwards outlined in her book "**Drawing on the Right Side of the Brain**" [21] in 1979 (with major updates in 1989) .

Plainly, as I see it, whether she knows it or not Zeng [15] is introducing a tiny brush into ***drawing skills*** - a shifting and an addition to ECG interpretation - by employing what are now recognized **hemispheric modes of brain function.** She does this in a tiny way in the graphics portion of her **G**SMM.

The ***sequence section*** of the G**S**MM approach, which includes both a similar "**six-step approach**"approach and an overt mapping to timing, (ie to the inches per second rate of the ink capture of the ECG tracing, intervals, etc) is in **DRSB** parlance or **split-brain theory** a *different* hemispheric mode of brain function.

Perceiving a graphic, or drawing a living model or a perceiving great mountainous landscape or perceiving a *line drawing,* (like an ECG), in **the way an artist *perceives it*** allows the artist to transfer that perceived image accurately to a canvas or a drawing pad. These are all **attributes** of the **right hemisphere of the brain. I know, l**ots of bold lettering there. That's the emphasis here though: the right hemisphere. That is key here.

Again, the ***sequence*** **function** of the **GSMM** approach is a mostly ***left*** **hemispheric** function. The ***graphics*** portion is a ***right*** **hemispheric** function.

Note: since the original **Robert Sperry Split Brain Studies** there has been gradations of what is absolutely defined as a left brain function or a right brain - in most right-handed people they are generally clearly defined, in others there is overlap. That there is **hemispheric specialization**, there is no doubt anymore. People who write left-handed seem to have more frequent access to this right brain function (ie perceiving as an artist) – since the left hand is mainly controlled by the right brain – and so incidentally are more frequently associated with artists. Statistically it's true. **But** it's also very important to state right here there are plenty of **right-handed artists** as well. Said a little differently ***handedness has no bearing*** on who can be an artist nor ***who can learn*** the techniques to access the "artistic" right brain. Yes, **learning to see as an artist is absolutely learnable.**

For the sake of this paper and to keep things simple, when we're referring to any "right-brain" functions, we'll just call them "**R-mode"** and we'll refer to any left-brain functions as "**L-mode**". Sometimes there's "brain" and "mode" swapped around but it will become clear what's being addressed.

Warning: large digression coming here in discussion Part II.....

So what does being an artist – or more accurately "seeing" as an artist – have to do with interpreting an ECG? Or reading an x-ray, or interpreting a CT scan, or ultrasound, or for that matter perceiving a 3 year old in respiratory distress?

If you can experience and internalize just a little about how to take control of **the shift** between **R-mode** functions and **L-mode** functions, it is my belief - no, it is my *conviction* - it will catapult your x-ray reading skills, CT scan reading skills, ultrasounds, will allow you to masterfully align laceration borders when suturing, even help you instantly diagnosis respiratory distress in a 6 month old with Croup or RSV. And towards our purpose at hand, will give you an insight and a **boost** into **reading and interpreting ECGs**. That was the sales pitch. Now I have to convince you.

[“**R-mode**” is the name given to those functions proven, generally speaking, to reside in the *right* hemisphere of the brain; “**L-mode**” is the name given to those functions proven, generally speaking, to reside in the *left* hemisphere of the brain. Much more to come.]

Big claim. How can you make that? Research on the human brain and development: What we know about the brain. Fast and furious, a little brain research education, human development, and the dominance of language

What we know (and medically speaking, we'll be keeping it 2nd grade simple). From the perspective of the ceiling, the brain looks like a **walnut**. It has two halves: a left and a right. As shown beyond a doubt – and with some overlap and gray areas – the left side of the brain controls the right side of the body, the right side of the brain controls the left.

How do we know this? Well for almost 200 hundred years observant folks like scientists have seen an injury to the right side of the head (or brain) might cause left sided weakness, left sided deficits, paralysis, etc. But these patients with right sided injuries could talk. Contralaterally, ie on the other hand so to speak, people who've suffered an injury or stroke **to the left side** of the brain had deficits on the opposite side of the body – **the right side**. But most noticeably, consistently, and devastatingly, **could not speak**. Further observation revealed **the hand on the opposite side** of the brain injury was also often deeply affected.

Over time it has been cumulatively observed further about **98% of right handed** and **70 % of left handed** folks had the neurologic deficit with traumatic **injury on the left side** of the head **lost** some part or all their **verbal ability.**

19th century investigators deduced since language – being such a highly developed skill, a skill that differentiated us from animals and even the most intelligent primates – was an expression of our preeminence amongst God's creatures. Language and speech were couched together and thinking was a derivative of both. Language and its derivatives were seen as dominant *human* features. Thus the left brain, home of language, speech and *thinking*, was the dominant side of the brain.

Derivatively then **the right side of the brain** has proven to be the minor brain; in Darwinian circles deemed the less advanced brain – and later judged as probably the under-developed brain. Therefore it (right bran) was the **subservient** brain, maybe even the *expendable* brain. At best it was subservient to the left brain, carried by the left brain. A sort of asymmetric Siamese twin growing out of the same brain stem along for the ride. (the will smith movie and the dood - the alien with the double head --- men in black!)

A major conundrum: the corpus callosum

Still, this structure, the corpus callosum, this giant dendritic neurologic bridge connecting the two brain hemispheres posed a conundrum. Why an effort of such magnitude by Mother Nature: all those upon millions millions of nerve fibers which **when severed** displayed no noticeable outward behavior?

Major animal discovery. In the 1950's Robert W Sperry and his team: the discovery. In their animal studies proved the corpus callosum was a conduit of memory and learning between halves of the brain. [34]

Human experiments : In the 1960's Sperry and his team at Cal Tech, opportuned to apply their research and ingenious experiments to humans. [22]

Who would they do their experiments on? In this period neurologists and neurosurgeons were the last stop treating patients with severe, rampant, damaging and debilitating seizures. They had seen in animals the termination of similar seizure disorders by performing a ***commisurotomy***: a complete severing of the corpus callosum. They tried this on humans. The experimental procedure seemed a success: at least from the outside. The seizures were for once controlled, and there was no outward signs of any serious new deficit: they walked, talked, played sports, by all accounting behaved in a normal fashion.

This is where the Sperry team stepped in: an opportunity to study follow up on these now “split-brained” patients.

Jumping way ahead, the first discoveries: it seems the right hemisphere, minimally, could no longer be considered a loafing tag along. Both hemispheres were involved with both higher and very sophisticated functioning. In fact in time they deduced what most of us now have at least heard it mentioned in passing or take for granted the the attributes of the left and right hemispheres. When discovered, and still now when I reread the account, skills issuing from, originating, seated and housed on one or the other hemispheres of the brain are surprising, shocking, even miraculous.

Another startling conclusion: In these studies the **right** hemisphere revealed it's *unique way of perceiving the world*: in fact its own decidedly distinct reality. And their studies reinforced the prevailing opinion - though now just an observation - the **left brain** was the seat of language, and was therefore in fact still **the dominant side** of the brain: The left hemisphere still had brain dominance.

Some amazing skills

Through Sperry et al's subtle and ingenious experiments in both commisurotomy and and normal patients they further uncovered the right brain was the seat of flash understanding, emotions and has the ability to confer an emotional affirmation of an agreement, an emotional underscore when both hemisphere's conclusions are aligned. (This more demonstrable in subjects with intact brains). The right hemisphere truly has it's unique way of processing and acquiring information. Modern research tools like MRI, PET scan etc. and further ingenious experimentation confirms what was ;learned in1960's.

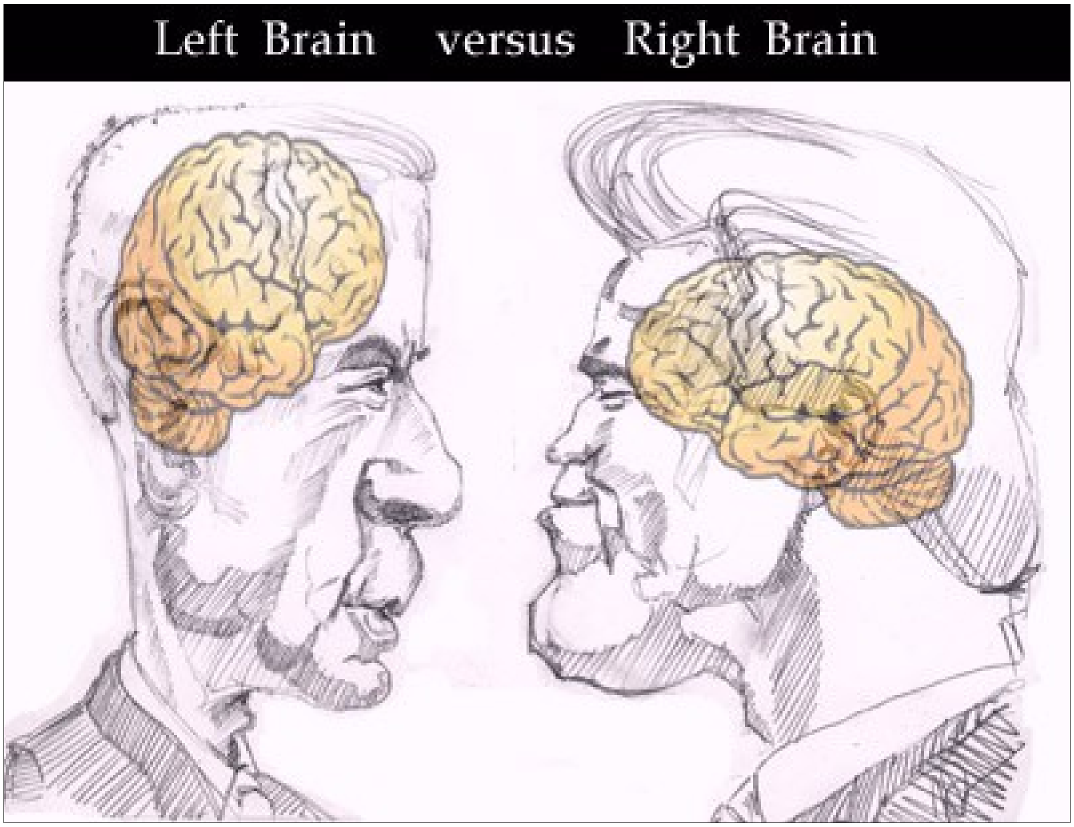


Illustration by jeff kasbohm

Quick summary: differentiation of the 2 hemispheres:

Left hemispheric characteristics	**Right hemispheric characteristics**
Verbal: uses words to to name, describe, defne Analytic: figuring things out step by step, linearly, part by part. **Symbolic**: collapses interpretations of things "out there" into symbols, like a short hand face with a circle containing two dots for eyes, a dot for a nose, another circle for a mouth, 5 straight lines for hairs, a **"+"** sign for addition. **Abstract**: using a tiny characteristic for something that represents the whole. A distillation. **Temporal**: keeps track of time, sequencing Rational: conclusions bases on reasoned and facts. **Digital**: eg using numbers for counting **Logical**: comes to conclusions based on logic or by mathematical equation **Linear**: thinking in sequence of linked ideas, a 'train' of **Rationally** associated thoughts that converges to a conclusion. "If, then" thinking; inferential.	**Nonverbal**: awareness of things but minimal connection with words. **Synthetic**: putting things together to form wholes. Regroups, reconstructs. **Concrete**: relating to things as they are, at the present moment. In-the-moment **Analogic**: seeing likenesses between things, understanding metaphor, metaphoric relationships. **Nontemporal or atemporal**: Without a sense of time. **Nonratioanal**: not requiring a basis of reason or facts; willingness to suspend judgment. **Spatial**:Seeing where things are in relation to other things, sees how parts go together; forms wholes. **Intuitive**: makes leaps of insights even without complete information, forms hunches, sees patterns, feelings, or visual images; often makes leaps **Holistic**: seeing things whole, like in a "eureka!" moment all at once' perceives the overall pattern and structure often leading to divergent conclusions.

Adapted from **DRSB**, p. 40

An example of one ingenious experiment

While facing a dual screen, a **commisurotomy patient** would focus on a point flashed exactly at the center between the two screens. Two images were flashed for just an instant: a spoon image flashed on the left and a knife image flashed on the right. And the two images were flashed just long enough so each side of the brain could register the image but prevent the scanning across screens of the other picture.

The *spoon* (on the left screen) would be perceived by the visual right brain; the *knife* (on the right screen) would be perceived on by the verbal left brain. Said a little differently, each side of the brain would perceive a different image.

This is crazy...

Here's the crazy part. Depending on the manner of questioning, the participant gave different answers. When asked to ***name*** what had been flashed on the screen, the participant would respond **verbally** with confidence "**knife**". Strikingly, when asked to **retrieve** what was displayed on the screen from a box of items behind a curtain **with his left hand** , (recall left hand is controlled by the right brain), the participant would pluck out a the spoon. He couldn't see what was in the box but with his left hand could touch and handle the other items – which included both the knife and spoon – and he'd retrieve the spoon.

When asked by the experimenter to **name** what he had just retrieved with his left hand he would reply with a confused expression say "knife" (recall it's a spoon). And then amazingly would say "why am I shaking my head?". **The conclusion**: the dominant left brain would mistakenly name the object incorrectly while without a voice of its own, the right brain would non-verbally protest by shaking it's head. These were the first experiments where a **conflict between hemispheres** became apparent. [35]

Squabbling siblings, hand to hand combat

In another experiment the participant was asked to arrange objects to form a specific geometric puzzle shape – a task the right brain is much better suited for. Immediately the right hand (controlled by left brain) jumped out and tried to accomplish the task. The right hand fumbled, klutzed about, and when appearing lost the left hand (controlled by the right brain) would swoop in and try to do the arranging. As fast, the right hand reacted (left brain) would react and push the left hand away. This evolved to a point in the experiment where the frustrated participant had to *sit* on the left hand. When the experimenters suggested the participant use both hands: "the **spatially 'smart' left hand** had to shove away the **spatially 'dumb' right hand** to keep it from interfering". From p.31 Betty Edwards, DRSB

The Left hemisphere just has to have all the attention: it has to "trump" the right brain

What this and many other experiments repeated over and over, showed again: each side of the brain is specialize to perform specific, highly specialized, sophisticated processes. These experiments also showed repeatedly **the left brain's self-proclaimed dominance**, it's tendency to try to "run the show", and every show at that, i.e. to dominate the situation. Even if it's not good at it.

This finding was striking enough researcher **Dr. Jerre Levy** proposed perhaps the brain's asymmetry was an evolutionary development that could only fully specialize and mature if these functions were relegated to opposite sides of the brain: there's just too much conflict. Further, there's literally just not "room enough" for these two hemispheres to function well, nor to fulfill their evolutionary potential, to bloom so to speak, if not separated. [36], [37]

Way back to a time at the dawn of language: the price of a larger skull - To be back in the infantile state of mind where we operated in a mode of pure *observation* and pure *perception* poses a potential high cost and is one of the reasons humans as infants need so much protection. We essentially finish our pregnancy outside the mother – ie we are born early. The observational infant and childhood "playful mind" of many other species is a necessary learning period and also a very vulnerable time: the less natural instincts, the less we recognize danger. Even moreso in humans since our essentially premature hairless underdeveloped "ape" bodies allow an immature brain and *skull* to continue to grow *outside* the womb. [29], [30]

Why? It has been postulated that before the fontanelles and suture lines of the underdeveloped skull permanently cement close (at about age 35!) the human brain can grow to its adult size. Compared to our nearest relative, the chimpanzee, the human brain mass and skull are already oversized at birth. To grow any bigger in utero would kill the mother. To cease growth at the chimpanzee-sized brain case would limit the brain-space and skull size required for the evolutionary leap to the large headed, large-brained humanoid. All this in service specifically towards the immense growth of the cerebrum and cerebral cortex [29], [30]. Chimpanzees babies are much better adapted for survival than are human babies. Evolution was paving the way for using those longer limbs and eventually language [33] .

To review: the conclusion of decades of research: a large aspect of our brain means performing as *information processor*

Suffice it to say neurological research and split-brain studies have uncovered without a doubt the existence of the **dual nature of human thinking**. We have the verbal analytic, ma thematic, time-associating, time aware, naming functions of the brain's **left hemisphere**; and those which are markedly different: the visual, perceptual, spatial reckoning properties of the brain's **right hemisphere**.

Building skills: Crash course in a practical application of human brain development; the acquisition of Global skills and parallel learning tracts

Categories of **things we had to learn in no particular order:** fresh out of the womb through first year of life beyond instinctual reflexes we learned facial recognition (a right brain skill), we got introduced to and learned balance (in order to walk); we experimented with **spatial skills**, we developed a kinesthetic sense – i.e. where our limbs are in space, we experimented with the world: "this is hot, this is sharp, that hurts, *this sound* gets me fed, this gets me to be early with no dinner", and we started learning these before we could even speak and many we learned simultaneously. The things we learned before language, before our memories worked in language (ie actually *used* language) remain mysterious.

Many memories that are inaccessible, e.g. a lot of that process of how we learned to walk, run, orient ourselves to sound, light, to parents, to the layout of the living room, etc. are blocked from our conscious minds BUT nonetheless we learned. Those aggregate skills like walking, running, navigating (ie crawling) through our homes, those skills we all learned can be termed **"global" skills**. [38]

What are global skills?

Global skills are those skills made up of **component skills**. For example **walking.** As mentioned above we combined our learned and burgeoning sense of **balance**, which involved coordinating the **inner ear** vestibular neurologic contribution in concert with the visual **recognition of** edges, and corners, and elevations (like steps), judging how far or how deep, or hard or soft - all those **spatial dimensions.** These stimulated visual, sensory and kinesthetic reckoning. We gauged the drag caused by carpeting, and stepping over obstacles and the required **kinesthetic calculations.** We acquired a sense of where every limb is and was needed to go, and just how much **muscle power** contribution from "this part" of the quads was required, or push from the right small toe and arms to **navigate** a sudden list to the right. We eventually **learned names** for much if not ultimately all the things we encountered learning that trip from kitchen to bathroom, to getting aboard that big wheel, to getting dressed.

Once enough coordination was acquired, once we integrated unconsciously all those millions, even billions of pieces of input over and over: voile! We were walking. And we didn't give up until we had a decent working model where all those component parts worked smoothly together. At that point they worked outside, beneath and **hid away from our conscious mind**. Our brains had integrated all those component skills (vision, inner ear, middle ear, kinesthetic sense, spatial reckoning, gauging muscle power, angling the body this way and that, starting and stopping, and had now funneled all those **components skills and** thus **graduated** them into a **global skill**.

Branching out on the foundational skills: parallel learning tracts

We then **built on** those gateway and **entry level skills**. They formed the foundation and the trajectory point for later walking faster. We graduated to jogging, then full speed ahead sprinting. We didn't have to lean a whole lot new.

They were recombined and translated into skiing, bike riding, all kinds of sports, etc.. Riding a bike, e.g. had several new skills to integrate – they required risk, took initiative, produced failures. But with practice and repetition, we integrated turning the handlebars and eventually squared it with wobbling over our center of gravity long enough not to crash (R-mode). Eventually we got rid of the training wheels and rode off leaving our nervous parents (...until the next crash). We combined peddling and braking with an in-the-moment awareness of where we were going (R-mode). We learned the words and language of biking: spokes, pedals, chain, handlebars, derailleur, Huffy, Schwinn, Campagnolo, Sugino, etc (L-mode). We eventually integrated that again into an another **automatic global skill**.

We repeated the same process learning to ski, or skate, play basketball or football, or drive. Or read. Once experienced a few hundred times, learned now in a perfunctory way, installed into the nervous system: another global skill. We graduated to intermediate, then maybe advanced, even expert skills on top of those foundational global skills – all built on top of the component skills. Until each and every level became automatic. And automatic pretty much Forever. Playing guitar? Same methodology.

Sounds and language

Much the same we learned **sounds** – even earlier if not while in the womb (the sound of our mother's voice and even her belly sounds – we *knew* them). Again. Once outside the womb, we learned names, then how to form those words with our mouths, mastered the needed breath work. Phonetics. Feedback from our own ears and from those teaching us completed the feedback loop. One or two words, then sentences...

At work from before birth, through childhood, to a well-adapted adolescent who can read and write is what **Noam Chomsky** [23] calls somewhat controversially our "**Language Acquisition Device**" – that thing most unique to humans: Language. Some assert **our survival** literally was and is dictated by how well we acquired language.

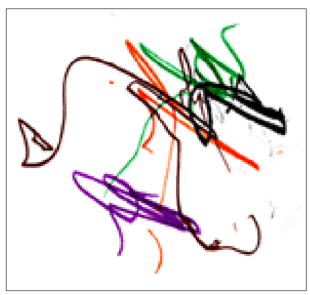
And again **like other global skills, language** is comprised of a **finite number of learnable components** like vowels and consonants, adverbs pronouns, intonation, syntax, and above all **attaching** a **meaning** to them.

Early on we attached meaning mostly to things immediately around us like mom, dad, family, things most relevant to us, closest to home. And to things that might hurt us or even kill us like the neighbor's dog or falling down the steps). And the more we were surrounded by siblings, and aunts and uncles, and attentive parents, neighbor kids, the more we were in a *language bath* and thus the faster our vocabulary grew, the more our symbols grew, and our brain's synaptic connections grew.

Again, all of those: **Global skills**. The whole brain was involved in their acquisition, and all were made up of smaller component skills that we learned to operate in unconsciously. Effortlessly.

Other burgeoning skills - the early "artiste"

As young artists we learned euphorically we could make marks: with markers, pencils, dirty barbecue tools, burnt wood. And walls – walls were a great open canvas for our burgeoning creativity. [We learned fast where we could safely do our art (like on paper).]



By Kyle

We also had an **age-related sequence** to our drawings: circles first. Then circles with smaller circles that represented eyes, a nose, ears – miraculously – all made from circles. Then a little later squares were added and triangles were discovered – which were great for teeth.

A body was invented (more squares); arms popped out beautifully from the hips, and stick-like protrusions appeared or more squares and circles - they sufficed for legs, feet, hands and figures. This was **a symbol system.** And it paralleled – or better said – expressed and **reflected brain development** just like language reflected directly the verbally interpreted part of our world. (Some have stated that language and writing is to the left brain as drawing is to the right brain).

What did you and that old Greek guy, Aristotle have in common?

What was happening? In learning language you were learning to "abstract", you were putting things into *categories,* you were making *generalizations*. "Hands" have little squiggly things called "fingers" sticking out of them, feet go on the end of this sausage-kind-of-thing called a "leg" and everybody, generally speaking had these things. In both ***words*** and in what you ***drew***, you were collapsing whole categories of experience (like figuring out "what do all hands have in common?") into a word, or a drawn symbol... Just like the ancient Greek Aristotle. Aristotle was the "king of the categories" (the big wigs in the university call it "taxonomy": the science of categorizing every dang thing under the sun. Analytic philosophy. The first four letters of that word pretty much describes the psychology of these folks - no disrespect intended.)

Ages 4-5, The Story telling age

So out of your compiled memories of hands, and faces, and dogs and cats and cars and houses, you constructed a "symbol" system. A visual "dictionary" of what those objects ***looked*** like to you, of literally ***your*** world. And, as child psychologists have pointed out fascinatingly, *your* relation to it. During this stage of drawing, you may have drawn your entire family, and expressed graphically *your* position in the pecking order. If your older brother or sister terrorized you, you drew them as giants with big teeth, and long claws grabbing at you. Your drawings told a story [32]. [see https://www.thecut.com/2014/12/what-kids-drawings-reveal-about-their-homes.html]

Ages 5-6: Landscapes, when you composed your artwork perfectly

At this stage you placed a yellow round sun in the corner, maybe with rays, a house in the middle, a door with a handle, you and your family in a row, all smiling. You had a sense of order about your drawings, a natural feel for composition. You were a Leonardo da Vinci, a Picasso, and a Hemingway all rolled into one.

6 y.o. Patrick with a sense of composition – and birth of realism- look at the claws on the T-rex foot

When our growing fledgling art skills hit a wall

Fast forward to age 9 or 10. Once in school we started a more specialized brain development, and more specialized requirements placed upon us more pressure academically and culturally. We now had the great **weight of learning academic "survival skills": like reading, writing, and arithmetic**: that is more rarefied and sophisticated language, rational thinking, critical analysis. Science. These were more specialized, ever deepening L-mode functions.

Self awareness and the heightened need for approval

Somewhere in there too came along the growing powerful interest in what others thought of us (the dawning of awareness of embarrassment and shame – actually that started way "back there", like age 18 months, but got supercharged here) and at age 10, 11, 12 or so too interest in the other sex – and more pressure to be accepted. [39]

The need to draw realistically – or very possibly the end of our art career

Conflicts of the developing brain: research has revealed about us at this stage of your development the desire and the need to draw *realistically.* We wanted **realism** in our drawing – how well we accomplished this usually determined how far we went in **our art careers**. If realism was accomplished, we got attention, praise, a reason to continue with it. (Thus recognition as an "artist"). Not accomplished? Our own self criticism, even self loathing, embarrassment all painfully fired. Who needs that? So we just moved on to things that got us more attention – things that got us the *good* kind of attention. The positive kind of attention like praise and recognition. Which in a Darwinian way means survival.

95% of adult drawing skills: stuck at age 10

Most adult drawing skills, and this is well researched, **have been stunted** at this 10 year old level – where either we had stumbled on to those realistic drawing skills - or like 95% plus of the population we did not. (There's a story in the Betty Edwards literature about a successful Ph. D. author and educator she taught who though highly accomplished academically and linguistically, was so ashamed of his stunted drawing skills he sought professional psychological help. Until he discovered the DRSB methods.

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Back to the *sovereignty* of language and the left brain:
avoiding the risk of being "in the moment"

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Language then is built around **abstractions**. Another way to look at language: it's an acquired repository of ideas, memories, of abstractions from memories, **signs** and **symbols** we constructed from very early on. By shear repetition and experience in the world we have at the ready our working lexicon: our **vocabulary**. That vocabulary has at our fingertips, well lips, sounds (ie words) associated with **meanings** and powerful **emotions**, and a myriad of **memories** and attached unconscious or partially conscious **mental images** and even **stories** that gives meaning for example to e.g. the word "tigers". If we're living where there are tigers, that word can carry *a lot* of meaning. And even more if those tigers are mean and nasty and hungry. And not just hungry, in fact if they're they're **man killers**. We'd have a bucketload of powerful meaning attached to the word or the visual "Tiger!" Heck, you know tigers are dangerous even if you've only seen them on TV. (Neurolinguistic Programming has a lot to say about this [40].)

Lions and tigers and bears, oh no!

Diving a little deeper: the noun "Tiger" is an abstraction. We don't have to go on rediscovering everything - like tigers - anew every time we encounter something regarding them. We have a powerful visceral emotional attachment geared for survival no less constellated around the meaning of that word. Tiger = *"run for your life!"*

From New York Times

So acquiring a rudimentary mastery of **language** (again **a global skill**) is one way we survive - and we can teach our friends, family, neighbors, our children, our students etc. the meaning of things without having to experience them at the cost of learning the hard way for ourselves or misinterpreting things. Like avoiding tigers. That's a pretty high pay off.

Thus the the judging, symbol-assigning, meaning-making, time-aware, abstraction-machine of the left brain comprises L-mode. And it (L-mode) is squarely rooted in language, constant usage, the meaning we apply to things, and survival.

So without the help of reason and abstraction, **we'd have been lunch for saber-tooth tigers.** Nor could we label and place things in ***categories***: we'd also never be able to agree that poodles, German shepherds, and huskies are all "dogs". That "man" and "woman" mean different things (when we hear the word "man" or "woman" we all picture something somewhat different than even our spouse will picture - but we can still agree what they, the *words*, generally mean). And that goes for ***every*** word we use! If we couldn't abstract, we'd still be in the stone ages. So thank God for the ability to "abstract". And this abstracting thing we do with language, is exactly the same abstracting we do in ***drawing*** our own symbolic version of things out there in the world.

The state of pure perception is not necessarily safe either
(Let it also be said the state of infantile "pure perception" incidentally is one effect of LSD and hallucinogens and even alcohol to an extent: they peel back the judging, symbol assigning, time-aware abstraction machine comprises so much of **L-mode**. The sober mind: "oh yea, that's a saber toothed tiger – meaning: gulp, RUN!" If there's no learned, re-callable symbol system: you're a meal.

The blitzed out, 'shroomed out brain, the brain on LSD, is too tuned-in to the experience of what is pouring in though the senses (externally through ***senses***, internally through the ***imagination***) – and thus, survival skills are deserted, forsaken, abandoned. (It's been said more than once that humans are the remnants of the most anxious, scared, worry prone apes – they were the ones who survived. The judgmental, discretionary brain built around memory and symbols (like "saber toothed tiger") is the brain function that contributed to our survival as much as any other function.

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The preeminence, dominance, if not tyrannical primacy, of language and the left brain / L-mode

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Our verbal, technological, linear culture and education only trap us more in the “language brain” - and more every day as our ability to make a living involves using technology, and understanding and working within the symbol system of keyboards, alphabets, mathematics, books, school, learning systems, and the memorized language systems of our automated worlds: our modern-day internet driven digital world.

Another clue: in culture and language to the resistance to “evil” left hand and the right brain by the left hemisphere.

There's a well documented history of the prejudice of right against the left: it's even found it's way into not only into our politics, it's eg found its way all the way e.g. of all things into *our ophthalmic exam*, Consider this: oculo-**dexter** and oculo-***sinister****.* *Sinister* connoting 'left', unlucky, evil, and of the devil. *Dexter*, meaning ***right***, righteous, godly. Giving more than a gift to having “dexterity”: if you're a writer with dexterity you're a righteous writer. Yes, this is lopsided. It's also well documented how left-handed writers were forced, even beaten at times during history to switch writing hands. Its also well documented these forced changes resulted in stuttering and other psychological maladaptations and hurts.

There are all sorts of other examples in multiple cultures and in hierarchies where we have this left - right and good - bad dichotomy. I won't go into them there (like the way shaking hands or eating with the left hand is considered an insult, as is in Islamic culture the left hand is consider unclean. Or the groom is always on the right, or the honored guest at the wedding is always on the right,

The need for the L-mode to applying a story – any story (stories that may harbor prejudice)

In fact one of the original Sperry researchers (Michael S. Gazzaniga, Ph.D) [31], uncovered the language centered, logical, problem solving **left brain's need** to **tell a “story”.** Applying meaning to a word is a miniature story. This is fast and efficient and again can save your life when confronted with a charging tiger. But look at this “story application” tendency *in a larger social mode*.

Example. Our detail trained and facial-recognition oriented ***right*** **brain perceives** a person with straight hair. Then perceives a person with loosely curled hair. But now perceives a person with hair that has curls tighter than say level “x”. And also perceives this person with slightly wide based nose. Even if the *perceived* person is only genetically 8 % of African descent, the **left brain** leaps in and **labels** (applies a story to) this person as “black”. 100%. Even if the *perceived* person is white skinned or nearly white-skinned.

If said *perceiving* person has been enculturated in the way White America might finally be gaining more conscious awareness of during this post George Floyd period, that interpretation could have serious conscious and unconscious racial overtones, emotions and prejudice attached. Ahh, the good old left brain taking simple objective observations and applying it's way-too-simple story and interpretation and meaning function. And repeated time and again that could make life miserable for all. Witness: the over powered hijacking left brain going too far again.

Attempts at tempering the left brain - **Some L-mode push against the Logical L-mode / left brain**

Alfred North Whitehead Bertrand Russel [28]: looking for proof that logic and even numbers have a foundation in the purity of logic – pushed logically they could only come up with 'set theory': where you have to agree on the rules of what makes arithmetic work.

This Whitehead-Russel argument was in part used by these modern philosophers to argue against **Immanuel Kant** in his **Critique of Pure Reason** and the primacy of logic and reason (that prima facie, if you could reason to an answer – a correct answer "all in your head" then obviously, logic is practically a god. **Whitehead and Russel** said "no, we're just a cat chasing its tail because we can only agree on the "rules of a game we've invented"." Which they essentially proved is all mathematics is.

Conclusion: there is no special power in pure reason other than that which we give it – even we can map some of it to the physical world successfully. I'm paraphrasing. That was a shattering claim when they came out with it. But then so was quantum mechanics – which came out at the same time - which flipped the theoretical scientific world on its head. The **Whitehead and Russel** argument is not much read. Maybe in Philosophy departments but not by much else. Surprised?

This also has been used by opponents of Rene Descartes's "**Tabula Rasa**": the blank slate we're born with – or that he believed we're born with. In effect disregarding modes of perception and the unconscious dependence upon it. In other words: no words equals no existence: "I think, therefore I am".

So when you're running deep in the language, symbol and abstraction driven L-mode of the brain, like we are after all the years of school we've gone through reinforcing constantly those L-mode, we are running in that mode learning the even more abstract ideas of medicine and "higher" academic learning. Pushing us yet deeper into L-mode.

And so it goes – all this reinforcement, prejudice by, and dominance of L-mode **gets flat in the way of the perceptual right brain**, or R-mode. Is there a key to Getting around this tyrannical Language brain: there is hope.

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The key to learning to draw: getting out of your mind ... (well out of the symbol dominated, abstracting *L-mode* anyway)... and back to "real-time" *seeing....*

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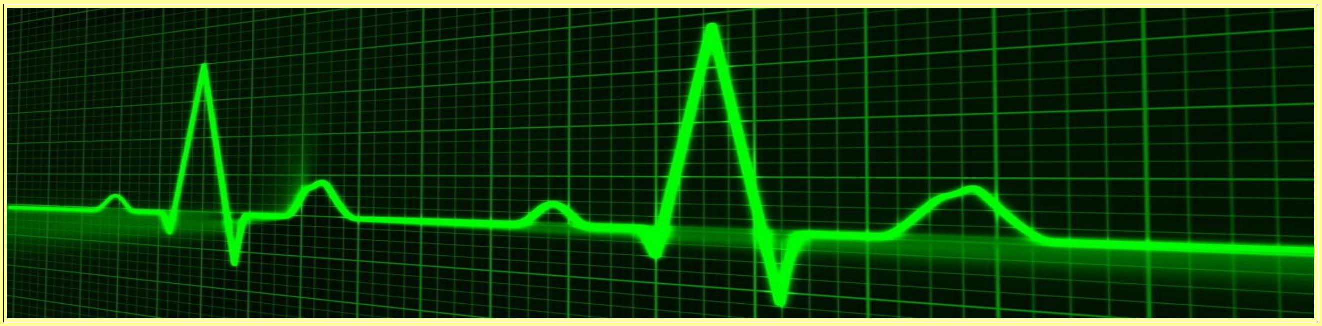
*"*REAL-Time" perception: what R-mode does best

So here's what I'm proposing: **by learning drawing techniques** – or playing sports or learning an art, or driving, or going for a walk, or doing improv comedy or daydreaming for that matter – *all* **pull us out of the symbol, abstracted, and language-anchored world of L-mode**. In fact all of the above when really mastered or really pushed can potentially pull us into what Ken Kesey and the "Merry Pranksters", and the original LSD culture of San Francisco and the Grateful Dead and the Dead Heads (I was never one), that Tom Wolfe wrote about in "***The Electric Kool-Aid Acid Test***" [24] of the 60's all aimed for: *the authentic experience of "**the Now**".*

By using LSD they went for "blowing up the whole [brain] pond". We don't need those drastic measures and we certainly don't need LSD. God no. But that was an artificial or drug-propelled entry (or re-entry) into **an altered reality** – much like people report after something as natural as mountain climbing, or an especially exhilarating game of basketball, or a mogul run or a good music concert or the act of writing really original poetry ('original' as in in 'emanating from the origin' original). Or after drawing.

Why did we feel refreshed? Is it because it was an escape of our overthinking, over-analyzing, overly judgmental brains? Or was it because we entered a whole different way of experiencing the world? Probably both. And probably as part of a continuum. (Some things allow you to slip deeper into the "non-linguistic worlds" than others.)



Maybe a little nutty sounding here for a paper built around interpreting electrocardiograms? ....

Slipping-in deep into the perceptual mind

And its in the deeper, or different, or even **altered modes** of experiencing or encountering the world - like drawing - that a whole new landscape literally opens before us. And that's the territory we need to be in to draw *accurately*. **The trick is learning to access it at will**. These are very similar modes akin to the mode the brain is in when drawing. And though learning to draw is not the goal here (though it could be) **learning to make this shift is** an additional **key** – I'm proposing - to learning **to read ECGs**. Or X rays. Or CT scans. Or be a master ultrasound operator or interpreter. Or be a painter or a kick boxer. Global skills: made up of component skills, employed all "**in the moment**".

Going to the pinnacle here....

Or if you're dropping into, **accessing really deep, subtle feelings, the memories**, the emotions and awareness of the emotional blocks that construct an **identity** and reveal the perception that "wow, I really *do* have prejudices against people not like me". A fish finally recognizing the water he's been swimming in, surrounded by all his life; those little awarenesses that if you didn't shut off the constant judging and analyzing and verbiage and verbal baggage and self-protecting, ego-preservation action of our left brain, our L-mode, that realization, or the meaning of a primitive book of chants, or the evoked images - *the awareness* of those would never had bubbled up to be made conscious - had you not shut off the naming, judging, identity clinging self-perception L-mode part of your brain. Thus you got fully "**open to the moment**" R-mode allows you to be aware of.

AND combining both...
Combining the linguistic skills of the left brain, or L-mode, again when you learn to suspend the judgmental, naming, abstracting L-mode part long enough, you can then put into words all that wild stuff that's bubbling

up out of your deep subconscious even your night time dreams; you can put into words what your R-mode is presenting perceptually to your “minds eye” and to your semi-conscious “emotional body”. **You've now combined both modes** and you now have the skills to write originally, to record what comes out of you – to be a for example a real writer - and original writer or artist. Or you can finally make sense of Jung's archetypes – through your *own* experience, on a personal level; or you can finally become aware of and confront a traumatic childhood event that has hobbled you all your life: allowing you now to *finally* live an authentic life. Thus allowing you to see, to perceive like **Leonard Cohen** so amazingly said in his song '*Anthem*':

“there's a crack in everything, that's how the light gets in”.

That's where this stuff can go.

The extended 4 dimensional spatial skills (drawing is a two dimensional version.)

The skills you need to learn to draw are already within you **and thus the skills to learn to interpret ECGs** more rapidly and efficiently) . How can I say that?

Look what happens when you're playing like **whats happening in biking?** Or skiing, shooting a basket? It's unconscious awareness of all those global skills AND the same component skills of drawing: add the 4th dimension of time and you have the experience of being in an **“in the now”** experience of edges, masses, changeling masses foreshortening – all in motion in the 3D world! Just like doing an RSI intubation, or guiding the ultrasound probe – and reading it, or reading way through an engaging novel or guiding a fiber-optic colonoscopy scope through the transverse colon (sorry, wrecked the mood there :-) But it's true. Or parallel parking your car. Think of how, when at the last moment you had to fly over 2 lanes of rush hour traffic to get to your exit, how you couldn't talk? You were switching modes.

Or i**f you're a writer** really pulled into describing the 3 dimensional scene in your head: the green of the amazon jungle: great fanning ferns and rope-like vines – the Amazonian Ayahuasca trees with spiraling snake like branches, the smell of coconuts, clammy sweat on your back, buzzing of giant river mosquitoes. The sound of sawing wood, the smell of insect repellent, the sublime flap of a Harpy eagle swooping. Monkeys howling off in the distance, echoing...

From: Fictional TV Stations Wiki Fictionaltvstations Wiki – Fandom At the Movies (U.S. Syndicated Series)

A fascinating aside from the movies: Screenwriting teacher **Michael Hauge** talks in his books the point of change in every main character (or characters) in a successful film: the moment of growth and facing the truth: when the protagonist has to stop saying “I can't do this, that's not me, I could never do that” when he or she lets go of clinging to their pre-formed, rock solid “**identity**” [revealed in those very statements “I can't do this, that's not me, I could never do that” – yet it's something you've always wanted to do or change] and starts to come into what Hauge calls his or her "**essence**" [25].

Identity is **the story** we tell about ourselves. Essence is what is left when everything else is torn away and you're left with the prospect of actually having to face your fears, face your resistance, face your *story*, and throw all that to the wind and actually walk through the simultaneously scalding and quenching waterfalls of actually taking steps of doing what you've always paid lip service to doing or being what you were put on this planet to do or impact. Until that moment, there's no growth and the story cannot move forward. It's never easy and its rarely painless.

- in **Chinatown** Jack Nicholson scene in where he actually slaps Faye Dunaway's character where Jack confronts her about the kidnapped girl – who we learn is actually her daughter, and the father is *her (Faye Dunaway's)* father. She overcame the terror of revealing her past to PI Jake Gittes. "She's my daughter!, she's my sister!".

- the blinded **Samson**, finding the strength to pull in the pillars he's chained to collapsing the temple and undoing himself

Side panel: The powers of perception: they must be toned down

There is much evidence as an infant we have to learn to cut off the incoming sensory information: it's too much. Too much light, too much sound, the silk-soft toweling we were captured in as we emerged from the womb at birth in the hospital perceived as the abrasive towel to the newborns skin. [Ever had a hand splinted or casted before? Its startling how sensitive your skin can be. I recall after getting my hand out of a cast how when I felt my face with the uncasted hand how smooth the skin around my eyes and along side my nose felt – and with the freshly out of the cast fingers I could feel every pore, every undulation – like the difference between glass (with normal fingers) and a sandy cobble stone street - of the same areas of skin felt with my hypersensitive hand.

Patients who have **recovered their hearing** through new miraculous procedures, or after opacified cataracts surgically replaced with crystal clear lenses have reported with frequency how at the beginning, light and shapes were undecipherable or in the recovered hearing cases, sounds were too powerful to bear, again undecipherable. With time and exposure "little-by-little" to both consciously and unconsciously relearn to control how much "stimulus" the brain would allow in.

Makes me think of in one of the more recent Superman series movies (**Man of Steel**, **2013**) how Superman explained to one the invaders from Krypton (Michael Shannon playing General Zod) after he was "de-helmetted" by Superman he would eventually learn how to filter out the incredible overload of incoming sound, sensation, light rays, the gamut of sensory overload his helmet – his mask – protected him from. (a startling parallel to Michael Hauge's **"essence"**:

[as they fly, Clark repeatedly punches Zod, they finally crash through a petrol station, causing a massive explosion, as Zod rises from the ground he finds his **helmet is damaged** and no longer working, his **heightened senses start to overwhelm him** as it had done when Clark was a child]:

General Zod: What have you done to me?

Clark Kent: My parents taught me to hone my senses, Zod. To focus on just what I wanted to see. Without your helmet you're getting everything. And it hurts, doesn't it? [27]

Point being here this powerful brain of ours had learn to sort out all the zillion bits of information poring into our senses. Without much in the way of instincts (a few) language, analytic thinking, “readin', writin', and 'rithmetic” helped us intellectually tame the outside world. **Awareness of an R-mode** helps us peel back a little all those things we have sought all our lives, consciously or unconsciously to control.

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Discussion Part III: Have I convinced you there's something else at work?

Back down to earth and applying the 5 skills of drawing to reading ECGs (or X rays or ultrasounds, or CTs, or mastering the physical exam...)

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After all that left brain / L-mode, right brain / R-mode rambling discussion above, after all that, well almost grandiosity, we get to water it all back down to acquiring or actually revisiting global skills. That's the task at hand. **So are you getting the idea??** Have I convinced you this this whole other neglected part of our brain, *your* brain's neglected other-functions, might be valid?

Back to global skills and the 5 component skills of drawing

Back to global skills, component skills, and the component skills of Drawing– putting on the training wheels. Lets name them:

the 5 skills of drawing:

1) the perception of edges
2) the perception of spaces
3) the perception of relationships
4) the perception of light and shadows
5) the perception of the whole: the **gestalt**

Ok, going to let the cat out of the bag. Twenty five years ago I started two web sites that taught drawing using the DRSB methods for learning to draw (and yes they look 25 years old – and please ***please*** **BUY NOTHING! - it's all open to the public at no charge** ...plus there is some coding issues :-) . You can also see my DRSB teaching certification in the appendix below. I'll be referring to these lessons readily here as references for you to view if you'd like to see exactly what I'm talking about or better yet experience it “firsthand” yourself.

You can copy and paste this link and see a quick (but much more in-depth overview of what I'll do here) **overview of the five skills**:

http://www.drawing-faces-and-caricatures-made-easy.com/drawing-basics.html#first-skill

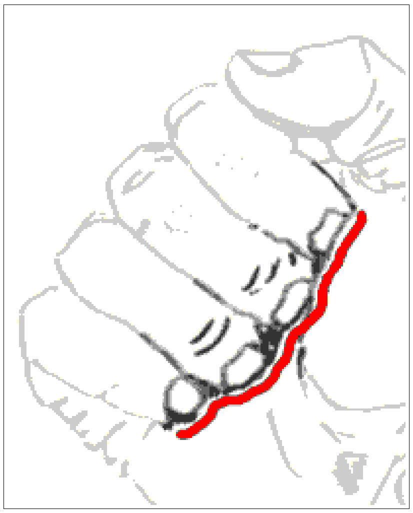
and another link with similar information:
http://ycdinsiders.digitalchainsaw.com/InsidersArtistLoft/lesson4.htm

Lets apply them. We're going to go fast here...

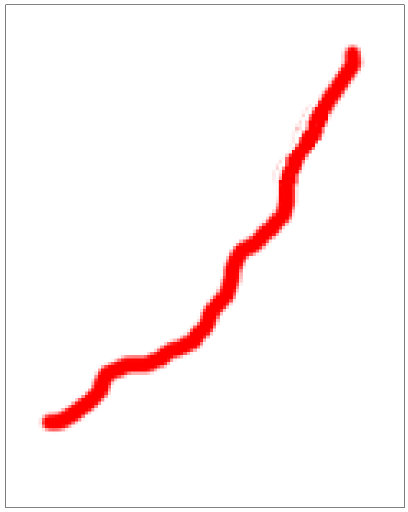
//

SKILL ONE: the perception of *edges*:

//

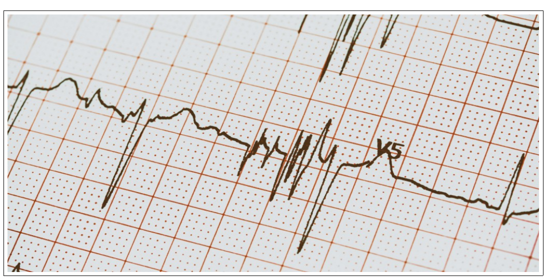


Finger tips and finger nails form an edge with your palm



Here's that same edge, but isolated

The way the fingers and the finger nails dig in to the beefy palm of you hand: this forms **an edge**. It is **a simple line** or contour. Not unlike the way an ECG tracing is **a simple line:**



When I point it out to you like that I'll bet you can see it: see those edges that is. Rather than seeing a jumble of fingers and palm and thumb and all those things you've **learned to name** in your life prior to this moment, your brain now has to learn to see ***right now, the intersection, the contours.***

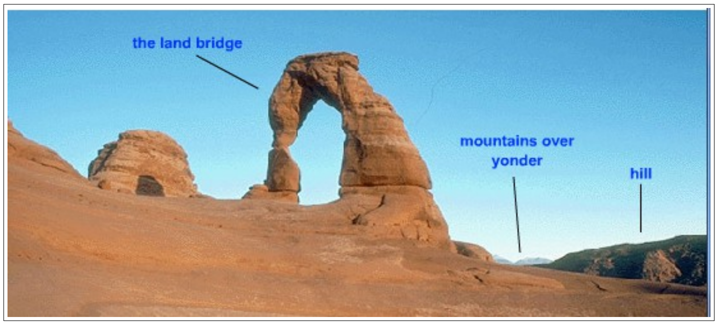
//

SKILL TWO: the perception of spaces.

//

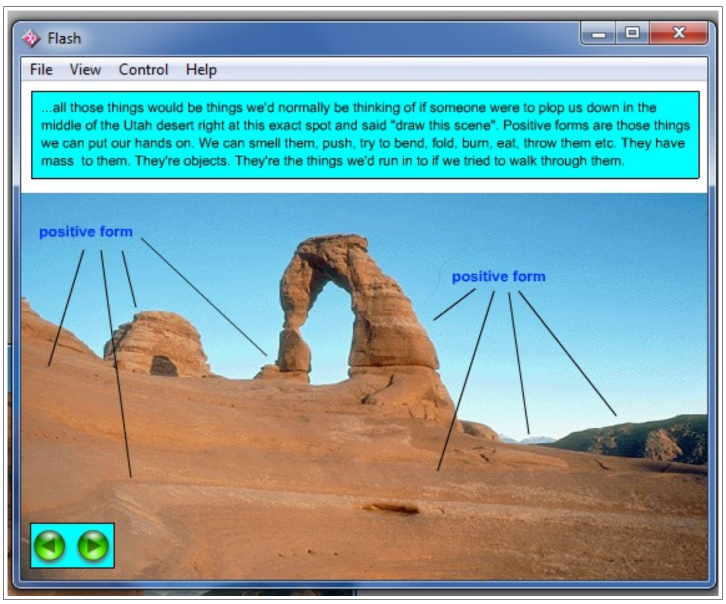
At first glance as you're seeing this photo consciously or unconsciously you've (better said your brain's L-mode) has labeled it something like "a scene form arches national monument in Utah":

And I'm sure you / we have great descriptive names for other objects in the shot:

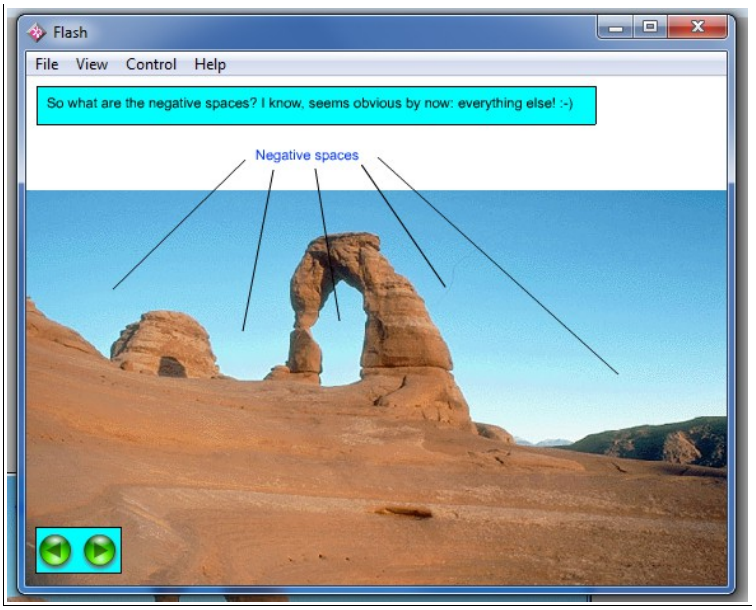


Land bridge, hill, mountains over yonder...

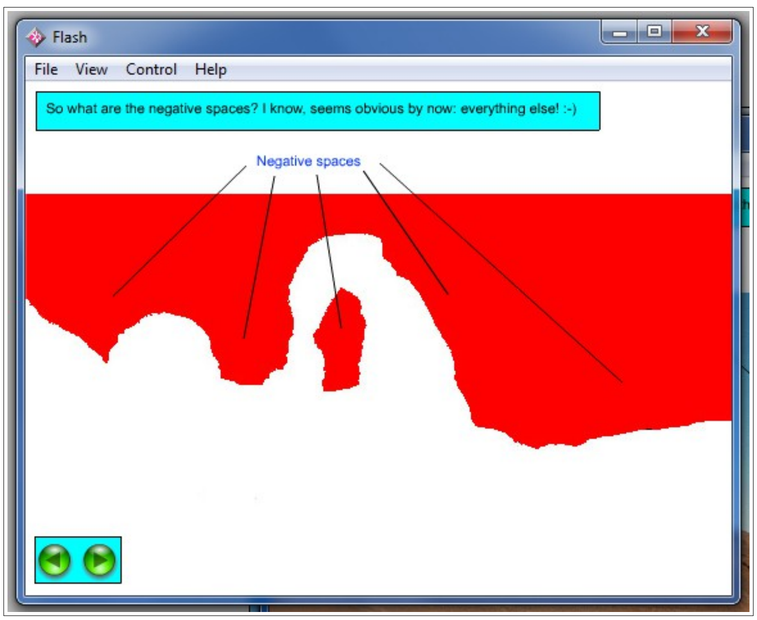
These objects ("land bridge, hill, mountains over yonder"), in draw-speak can be called "positive forms":



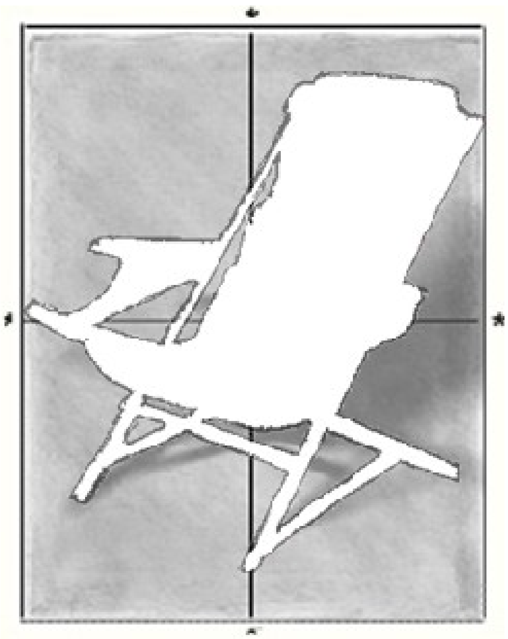
In this next skill of drawing and perception, we learn to see all the other forms in the photo as "negative spaces", i.e as standalone forms all their own:



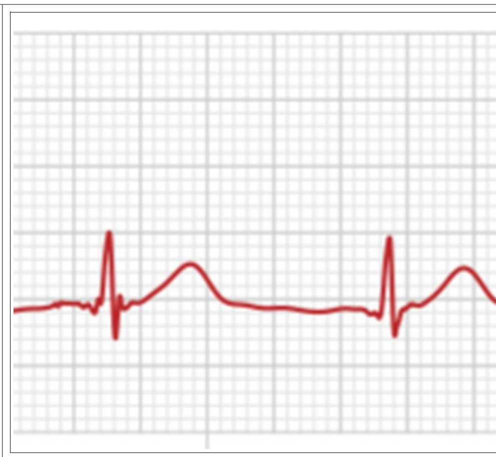
In this illustration, when colored all red, it's a little more plain to see: the **negative space** (the form of the non-object) as a *form* with a shape all its own:



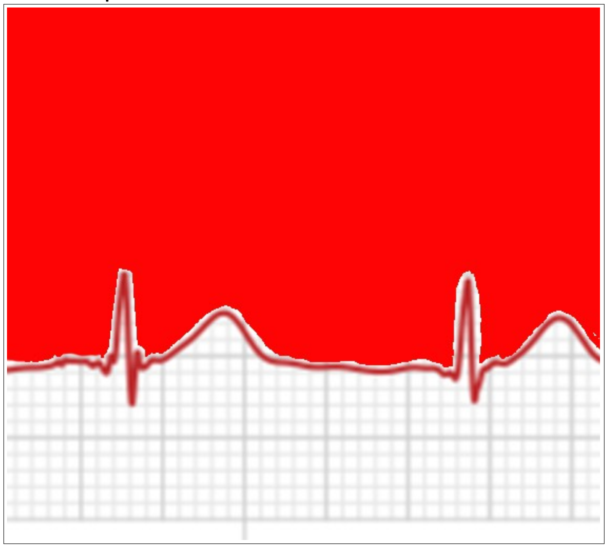
Do you see it (the negative space) in the following pictures?:



...Or in either of these two:



Let me help:



Yep, I told you we'd be going through this rapidly – but see the link in this blue side bar for more depth on this:

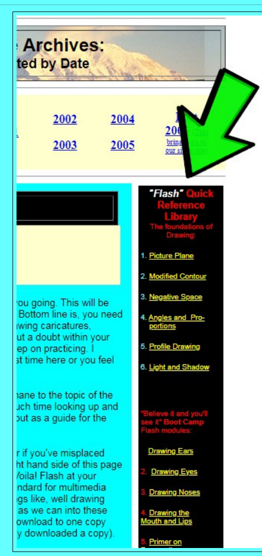
For an animated lesson: Click on link number 3 "**Negative Space**", in the **Flash Quick Reference Library**.
The below link will get you there:

http://ycdinsiders.digitalchainsaw.com/InsidersArtistLoft/archives.htm

http://ycdinsiders.digitalchainsaw.com/InsidersArtistLoft/from_the_top_neg_space_exercises_1.htm

In the **far right column**, that's colored black with the small yellow text, there are a series of "**Flash movies**" (the "**Flash Quick Reference Library**"). Your computer may block their download at first but they are fine. Or you could download the flash lesson to a "sandbox" area in your computer that scans them for malware. Anyway, here's the main page:

It looks like this when ready



The Flash Quick Reference Library

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SKILL THREE: the perception of *relationships*

//

This is a very important perceptual skill and probably the most difficult to learn. And learning it will not only make you a better interpreter of ECG's (or xray's or ultrasound, etc...) but actually probably less important to have down for fitting DRSB skills into your ECG interpretation skills. I'd recommend it, but if you're pressed for time...

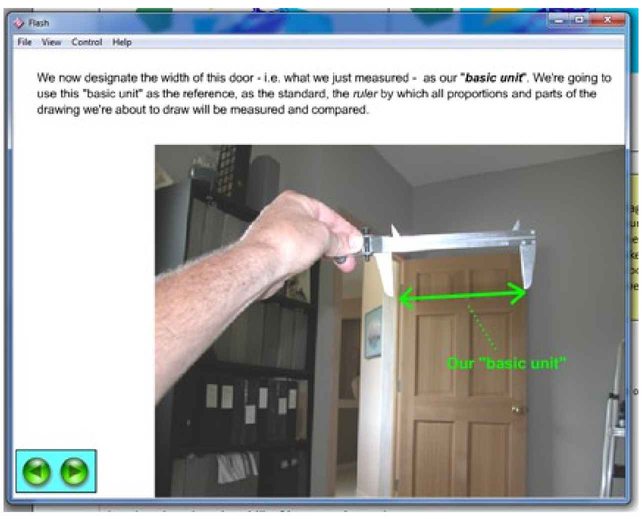
Essentially, this involves perceiving for example how parts of something you're trying to draw fit together. Or when you see the stereotypical artist illustration of the "one eye closed, other eye squinted, aiming with the thumb at an the end of an outstretched arm", what follows is what they're doing:

And as you progress through this centuries old technique and skill you'll see it's genius in how you gauge **proportion**. This is called "sighting". Employing a "**picture plane**" and a "**basic unit**", even a **protractor** help you gauge these relations. Understanding **foreshortening** is a very gratifying skill to master (Albercht Durer developed an ingenious apparatus and method to tame it). Its a mind-bender but learning this skill really propels your drawing accuracy.

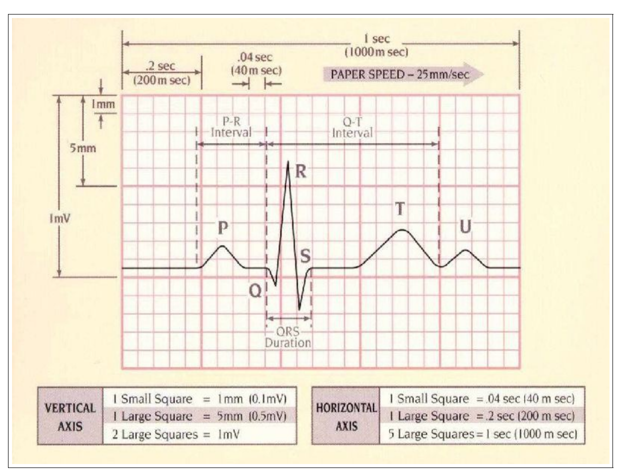
A teaser on the **picture plane**:

Click the underscored "picture plane" in the text above to learn more

No need to learn what "sighting" is right now but suffice it to say its exactly what you're employing if you're relating QRS width or QTC, or PR **intervals** with your **calipers**: you're doing exactly the same. You're relating scale to the finely generated squares in the paper the ECG is written upon:

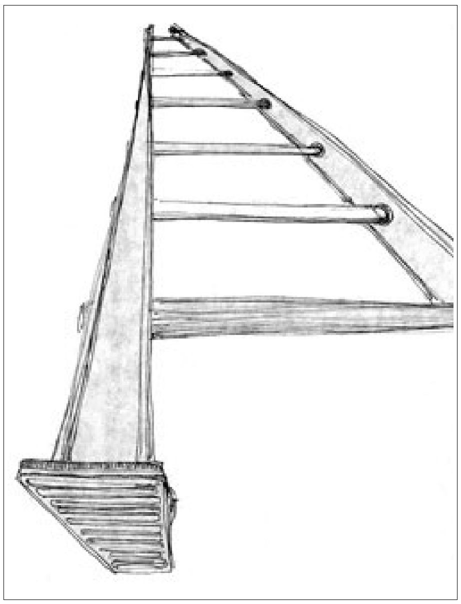


Relating that "basic unit"



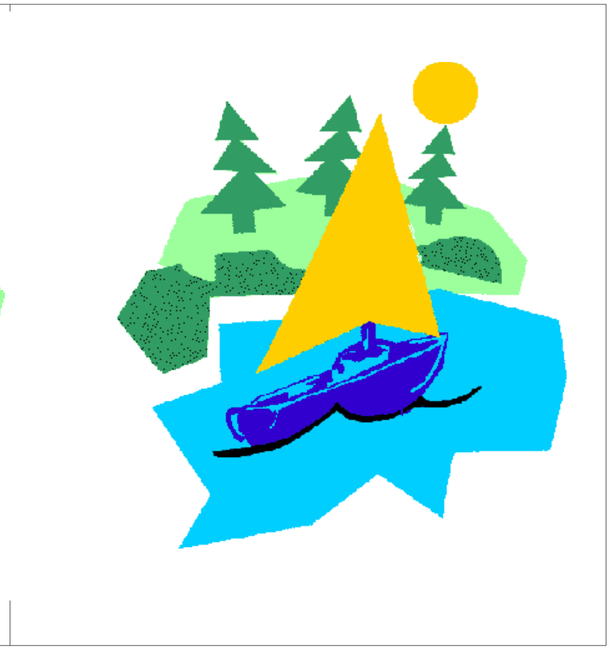
You're sizing up those relationships when you use the caliper in interpreting ECGs. Again see the links to the Picture plane or basic units above if you'd like to see more. [And quite frankly doing these kinds of measurements do let in a **modicum of the left brain** – not unlike counting **inspirations** or taking a **pulse**: watching someone breathe - looking at the sternocleidomastoids subtly contract, the sternal notch retract, ribs pulling up, stomach pushing out, etc – is a *skill of spatial perception*. **But counting against a clock**, for example how many in 15 or 30 seconds, this is a *left-brained* skill. This has a lot to do why these two vital signs are so often inaccurate.]

But there's more to an ECG than just basic units and squares. Those contours, the actual tracing has shape too. Learning to relate those shapes visually is a major benefit of acquiring this skill. A simple intro to the "jigsaw" concept of how a picture's parts might relate (see the bottom of this page for more explanation): http://ycdinsiders.digitalchainsaw.com/InsidersArtistLoft/lesson4.htm):



The "foreshortened" ladder

Tilting a **3D object** in space, for example a ladder, or an **ultrasound** view of the heart while changing the axis view (e.g. parasternal long axis view versus four chamber short axis view, etc.) involves this interpretive skill. You don't need to be able *draw* a tilted ladder, but you will improve your ability to interpret that ultrasound measurably if you've had exposure to this skill. But don't worry, in essence you're using this skill everyday if you're say, riding your bike off-road through a winding trail full of obstacles.



Quoted from that “digital chainsaw” page linked below (BTW - don't need permissions - I wrote it :-) :

“The evergreen tree forms a drawable contour against the orange sail (you could represent it with a diagonal line). The waves share an edge with the boat hull. In fact, the waves in this picture are actually a contour between the boat and the water. The sky around the sun, the tops of the evergreen trees, and down the sides of the picture (suggested by white) is a negative space - complete with a shape of it's own. The blue lake, even though it's an object with a shape of it's own, forms a *negative space* against the dark blue hull of the boat, the mast and the orange of the sail. Every part of the composition has a job to do: it has unity and so we can make sense out of it”.

http://ycdinsiders.digitalchainsaw.com/InsidersArtistLoft/flash-angles-and-proportions.htm

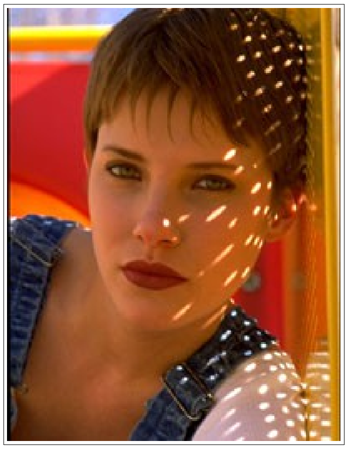
Using a picture plane helps you sight proportions and understand the relationships between edges, contour,. Lines, positive objects and negative spaces.

//

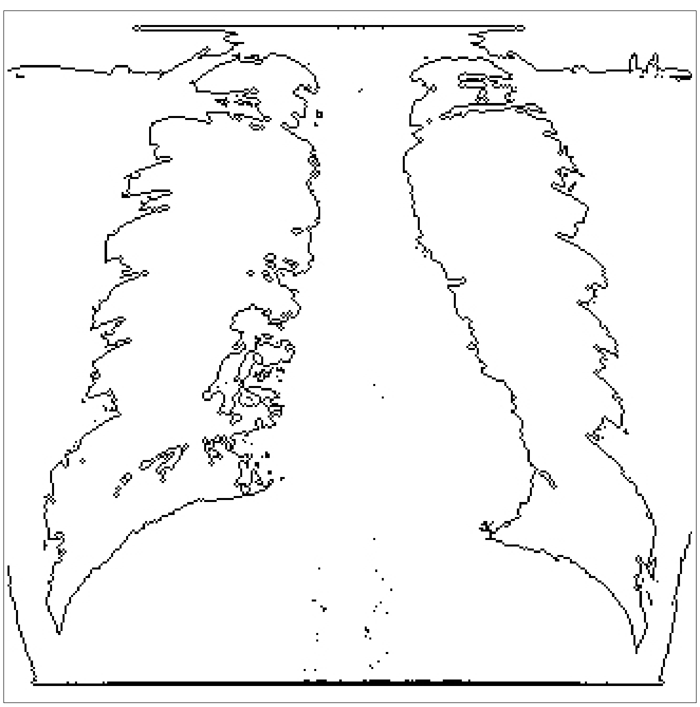
SKILL FOUR: the perception of light and shadows

//

Closely related to the skill of interpreting color – but needs to be understood first - is the skill of **perceiving light and shadows**. Our brains are too fast and too accustomed to adjusting for light and shadow to actually allow them to “register” in our conscious brains. You've seen the custom of **flipping an xray upside down** to see irregularities? Especially chest xrays? That because **radiologists** realized when they got too accustomed to seeing for example thoracic anatomy, as you see in PA and lateral chest xrays, flipping them made them unfamiliar again – and thus the irregularities stand out. Or changing the **contrast:** makes edges, margins and contours more obvious:




Understand this skill and you can see it's value e.g. in seeing more into xray interpretation



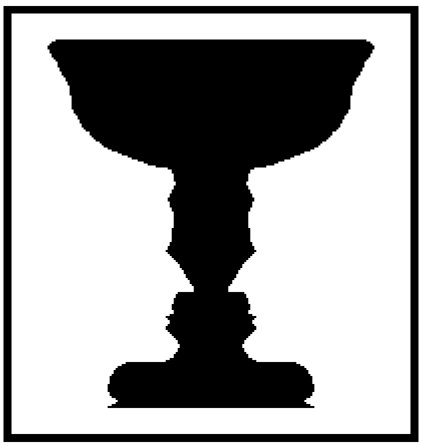
What could this be?

///

SKILL FIVE: the perception of the whole: the *gestalt*

///

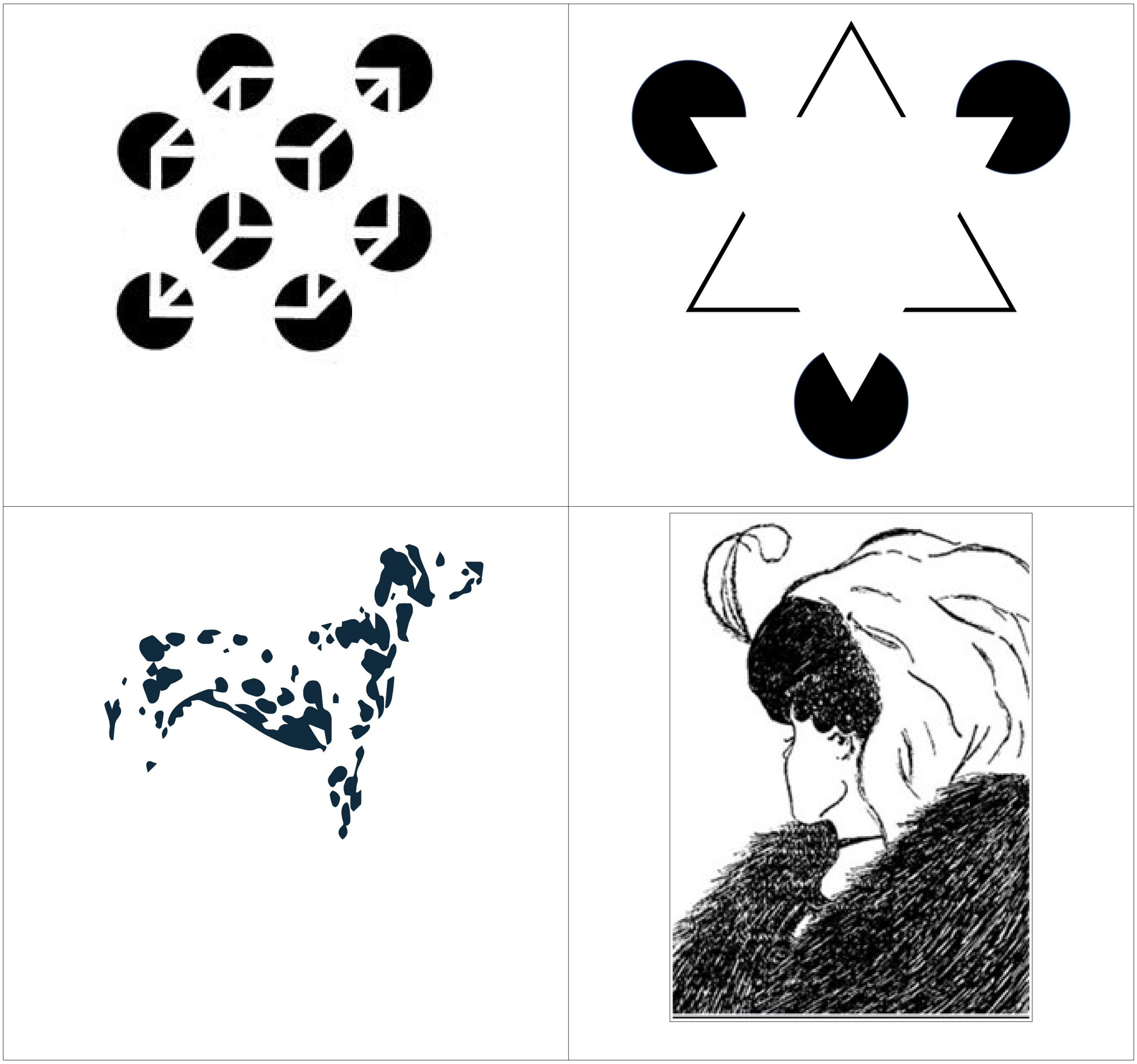
This is probably the most mysterious and unconscious skill of drawing, of art, but most of all of ***perception***: the recognition of the whole, the snap paradigm shift of seeing for example the old woman / young girl paradox in the picture below. Or for example in this next picture – is it a vase? Or is it two faces looking at each other, nose to nose? You decide:



The famous "Vase or Face" paradox

Here's an example of the brain applying meaning to cut up and manipulated letters – fascinatingly this involves input from both brains but is actually the right brain's final decision to decide: the left brain applies the meaning. The right brain does the recognizing:

A couple of fun facts. When you learn a new language, when you're slowly passing through the "translating" stage of acquiring that language, you recognize right away how little meaning words have. And the act of translating takes a good deal more impact of that meaning away. When you start getting more proficient, it's still difficult to feel the full emotional impact of e.g. a movie when the you're watching it in your non-native language: the words do not yet have a history with built-in impact. That takes time. **On a different note**, it's also been shown that *great art* actually lights up different parts of the brain: the right brain to be exact – and mind you, in people who are *not* artists.



What do you see in the above? Your brain is making a leap in every case – especially the young / old woman illustration. Fascinatingly, in the cube and triangle examples above split brain patients can see the shapes – but if you were to complete the outline of the *circles* which form the "infrastructure" or the suggestion of the shapes, the commisurotomy patient can no longer perceive the contained shape. (See page 5/6 of original Sperry et al researcher Michael S. Gazzaniga for more in-depth explanation: https://personal.utdallas.edu/~otoole/CGS2301_S09/7_split_brain.pdf)

//

Ok, that was rapid fire through the five skills of drawing

//

Review again: the 5 skills of drawing:
the perception of edges (and contours)
the perception of spaces
the perception of relationships
the perception of light and shadows
the perception of the whole: ie the gestalt.

Master those skills, make them automatic and – **voile**! You now have another acquired **global skill**.

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Discussion Part IV: wrapping this up

///

Quick excursion back to back to Zeng [17] – the **GSMM: graphics-sequence memory method.**

In her graphics section of GSMM, here's how she represents her process:

1) you memorize what all *the normal parts* of the ECG *look* like, then **2)** you *compare* side by side pathologic ECGs with those normal ECG's. Next you **3)** *analyze* those ECGs against numerical values known to be characteristic of that rhythm or dysrhythmia; lastly **4)** you try to *memorize* it all (mostly the normals) – bit by bit. (She offers a fairly idealized view of the ideally illustrated version of the pathology:

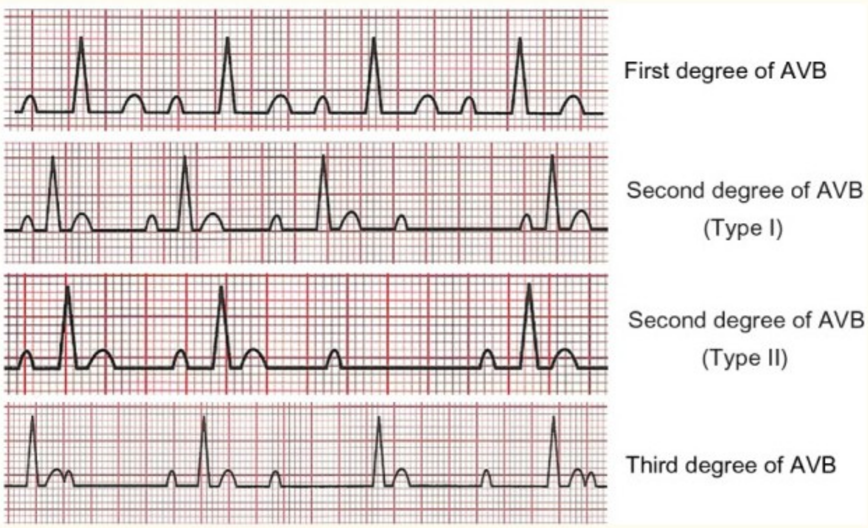


Figure 2

Schematic diagrams of atrioventricular block (AVB).

Amazingly, this is seen as a remarkable idea in academia – I've seen several authors and teachers of interpreting ECGs describe the **traditional approach** (where you learn the clinical presentation of the patient and the correlating ECG most common for that affliction) versus the so-called **alternative approach** where you learn ostensibly just the actual specifications of a dysrhythmia as revealed by e.g. the **Six Stage Method** [41] touched on above (i.e. going through “rate, rhythm, axis, interval, ST elevation or depression, overall morphology of P, QRS, ST, and T, congenital signs...” etc.) Sure seems some places are doing both. But this two tier / binary approach is what is so commonly referred to in the academic literature - and are referred to as *separate* approaches - one or the other *but not both* generally taught in any one medical school, PA, NP, EMT curriculum). Only so much time in the day.

Here's where, for me, it gets more interesting...

In the graphics portion of Zeng's approach, every step of the way outlined in his/her illustration below, she (I actually don't know if Dr. Rui is he or she – in Chinese culture the name is used in both genders), she is doing the visual “in the now” spatial evaluation of each section of the ECG. If I had no drawing experience or training the huge question becomes how do you approach her method? Seems obvious but what really is a “P wave *analysis*”? Or a “PR interval period *analysis*”? How many ways can you evaluate this? In what dimensions? In vertical derivations from norms? Or in actual **perception** of the **edges**? **Angles**? In terms of **units**? In their **relation to the whole**? What are your visual, spatial reconnoitering **tools**? :

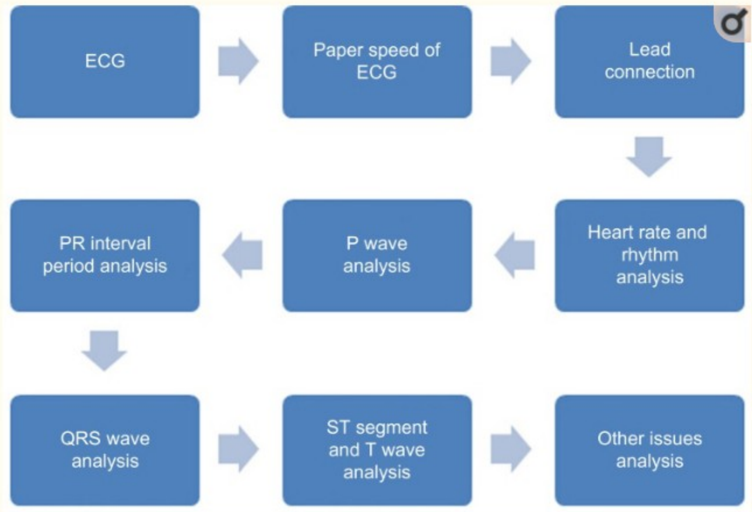


Figure 3

Analysis diagram of electrocardiogram (ECG) by graphics-sequence memory method.

From Zeng

Sure you're going to compare these to the “ideal normals” in terms of millimeter lengths and how far the tracing deviates above or below the baseline, etc. It's a given you're going to compare all your tracings and intervals to a list of “normal” intervals like the **left-brained** types of analyses boiled down to hard numeric facts and evidence as outlined in this table – and we all recognize these:

Table 1

Electrocardiogram (ECG) content analysis by graphics-sequence memory method

Analysis content	Normal	Abnormal
Heart rate	60–100 per minute	<60 per minute >100 per minute
Heart rhythm	Regular	Irregular
P wave	Sinus P wave	Non-sinus P wave
PR interval period	0.12–0.20 seconds	<0.12 seconds >0.20 seconds
QRS wave	Normal	Abnormal voltage
	QRS wave	Abnormal electric axis QRS duration augmentation Pathological Q wave
ST segment	Normal ST segment	Elevation and depression of ST segment
T wave	Normal T wave	Tip, flat, or inverted T wave
Other issues		U wave Abnormal electrolyte-related ECG Drug-related ECG

From Jeng

But my point is there's **1)** no direction given (nor would I expect it) in the Zeng outline nor in medical schools in general) on how much *richer* your description, ***perception*** and ultimate interpretation and **diagnostic accuracy** *could* be, and **2)** but **could be** if students were given just a few **entry level drawing lessons**. The mental apparatus and vocabulary you *could* have to evaluate any visual test (ecg, xray, US, CT, real time physical exam) would be significantly amplified and I believe could be so much more accurate. Did I already say more accurate?

Those **visual** analytic steps suggested, simple, bare and as understated as they are in the "**G**" **graphics** section, are right out of the drawing and perceptual skills department I just explained above (i.e. the 5 skills of drawing).

Reading ECG's clearly draws on both sides of the brain – but the problem is in the teaching of them: learning R-mode skills pulls so asymmetrically *against* the language centered, analytic, readin', writin' and 'rithmatic side of the brain - the Left brain (L-mode). And anything Right-brained or of an R-mode nature has pretty much been stamped out modern academia. If you walk in with those skills, you're way ahead of the pack. But that person is the exception.

///

Here's my proposal: the main trick – and the good news

///

The main trick is **learning to access *at will*, getting into the R-mode of the brain.** And that is what the DRSB skills and lessons are all about. I described the skills required above, but the actual **acquisition** of those skills seems to be the great mystery. The good news is **you don't have to be an artist to have access to them**. I'll label them here (exercises to access your under-used right hemisphere) and if you're interested you can see them all in much more depth at the links supplied below...

So what's it take?!! to get into this R-mode, right brain, right hemisphere, spatial interpreting, blah blah blah, brain-inside-your-brain brain? (feel the left brain impatience there?)

Betty Edwards describes the process very well. I'll paraphrase: since L-mode is reinforced in all our approaches to learning, in reading, writing arithmetic, since **language** is an abstraction of the physical world, and since we also know through split-brain studies how badly L-mode, the language, number, rationality, linear and logic driven left-brain wants to fashion our interpretive approach to the world – i.e. how it wants to **dominate** *every* situation, be the star, to quickly pigeon-hole every perception to its advantage. In word, be a Donald Trump. So to get around it...

> **we must present the brain with a task it will reject and allow the movement from labeling and abstracting to a very different but complimentary mode of the brain that is built for *being in the moment* – a very different function**.

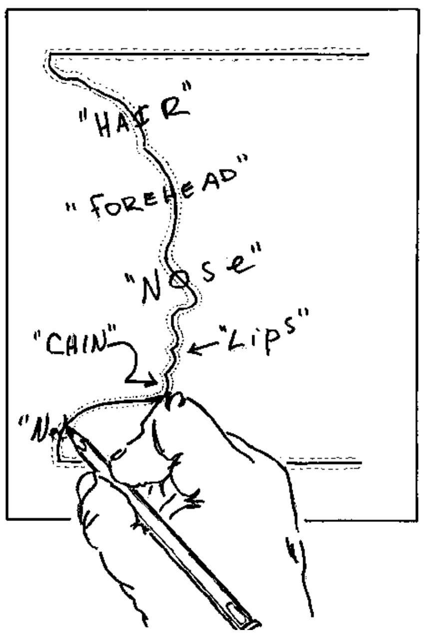
And further, we need to know how to **access those skills at will** or at least know how to trick our brains into that observant mode as needed. And that global skill - that skill set - can be built like any other skills you've learned in your life.

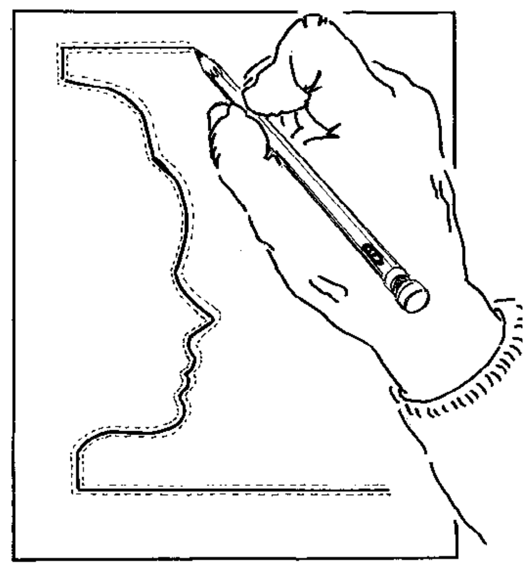
//

These are the DRSB entry-level exercises where you slowly **acquire** these **perceptive skills** (I'll just skim over them) :

//

1) Feel the conflict: don't just look at the vase-face paradox, draw it. Put the egg-beater to work in your brain and feel the **left-right brain conflict** while simultaneously naming and drawing the mirror image half of the vase-face (you'll get into depth how to approach this at the supplied links):

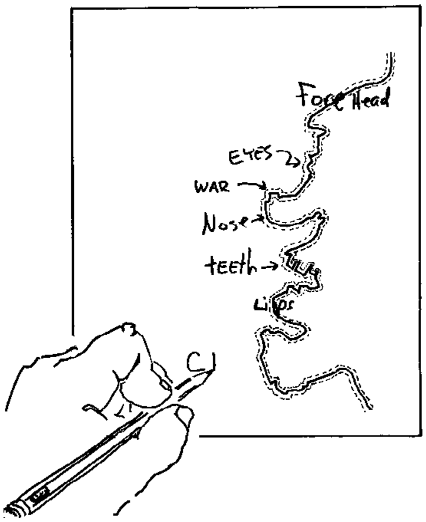


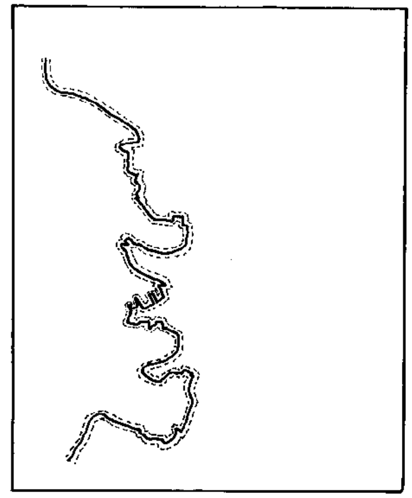


Click on the link below to see more in-depth explanation

http://www.drawing-faces-and-caricatures-made-easy.com/drawing-basics-II.html

2) Turn up the pressure: we're going to complicate the basic **vase-face** and make it a little more unrecognizable. Same rules as number 1: draw the reverse, the mirror image of the monster face:



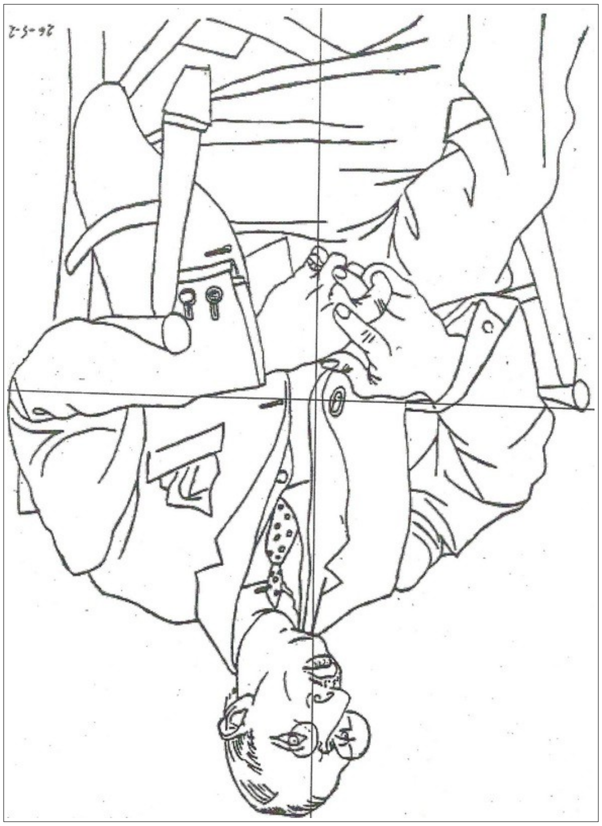


3) The upside-down drawing: you've felt the conflict in exercises 1 and 2, now let's really confuse L-mode, in fact lets get the left brain (L-mode) the heck out of here:

(Drawing something from a perspective we're unaccustomed to – like an upside down face or line drawing – this can ease our brains into R-mode):

Try drawing this

The Igor Stravinsky drawing being the most famous Betty Edwards example:



Igor Stravinsky

Slightly more complicated drawing

BTW - In carrying out these drawings it's also important to **draw the right side up version FIRST*, like a pre-test.*** Then **second**, try again drawing the upside-down version. You can look over the internet for before and after examples, but invariably students are amazed at the improvement between drawing the right-side up version and the version they've drawn upside-down.

Click for more upsdie-down drawing depth 1

Click for more depth 2

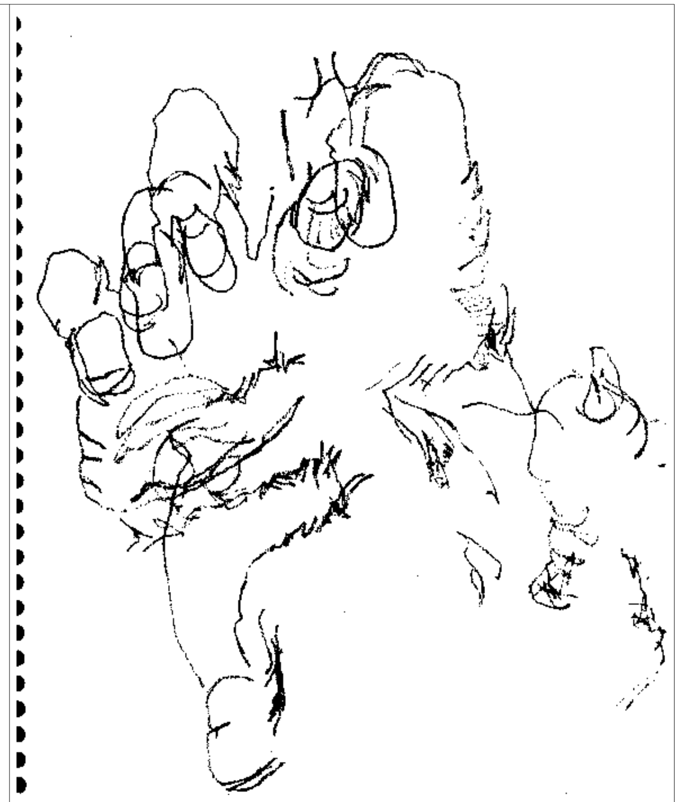
Click for simple figures to draw in the same upside-down mode

4) Pure contour drawing – this is the first lesson in really **perceiving edges and contours -**

This **may be the most directly applicable** introductory skill for aiding **in the interpreting of ECGs**. This involves really slowing down. *Waaay* down. Which ironically and painfully we generally don't have the luxury of that kind of time when working in a busy ER or Urgent Care center. Best to have this skill before being in the hot seat.

* Performing this exercise really pulls you deep into the perceptual right side of the brain.

* Results of this module generally yields rich, intricate, complex results like this:

We're **not looking for accuracy**, we're looking for **immersion** into the right hemisphere (R-mode).

Link 1 for more on Pure contour drawing

Link 2 for more several more lessons on Pure contour drawing

5) to introduce a little more accuracy into pure contour perception check out the following links on employing the "picture plane", perceiving proportion and angles, comparing sizes an scale, light, and shadow and multiple perspectives on accomplishing this – only if interested:

Link for stepping up to modified pure contour

The rest of these lessons all build on the first 5 – and might be more fruitful if you're excited about learning to draw – but would be especially helpful in accelerating interpretation of all the other more complicated imaging we employ in medicine:

6) **Employing the picture plane**

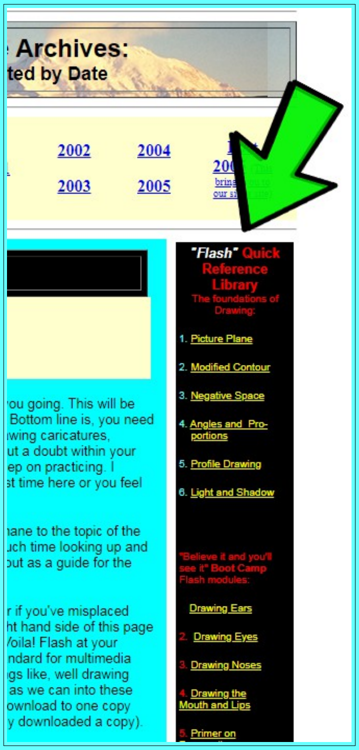
7) **Recognizing and perceiving negative space**

8) **Perceiving angles and proportions**

9) **Perceiving light and shadow**

And if you'd like to really go deep check out this page - and again that far right column of animation links:

http://ycdinsiders.digitalchainsaw.com/InsidersArtistLoft/archives.htm



Animated lesson links in that far right column

Pure Contour drawing

And finally, in the same way Zeng promotes comparing pathologic ECG's after first getting familiar with and **memorizing NORMAL ECGs**, that's exactly the method employed at my drawing site 25 years ago: **recognizing the average** face (approximately equivalent to "**normals**" in medicine) proportions and features of the head and face:

And especially in the "boot camp" section, you'll see a whole bunch links if you scroll a ways down the "**archive page**".

Clicking on icons like these on that page:

...will link you to informative Flash animations.

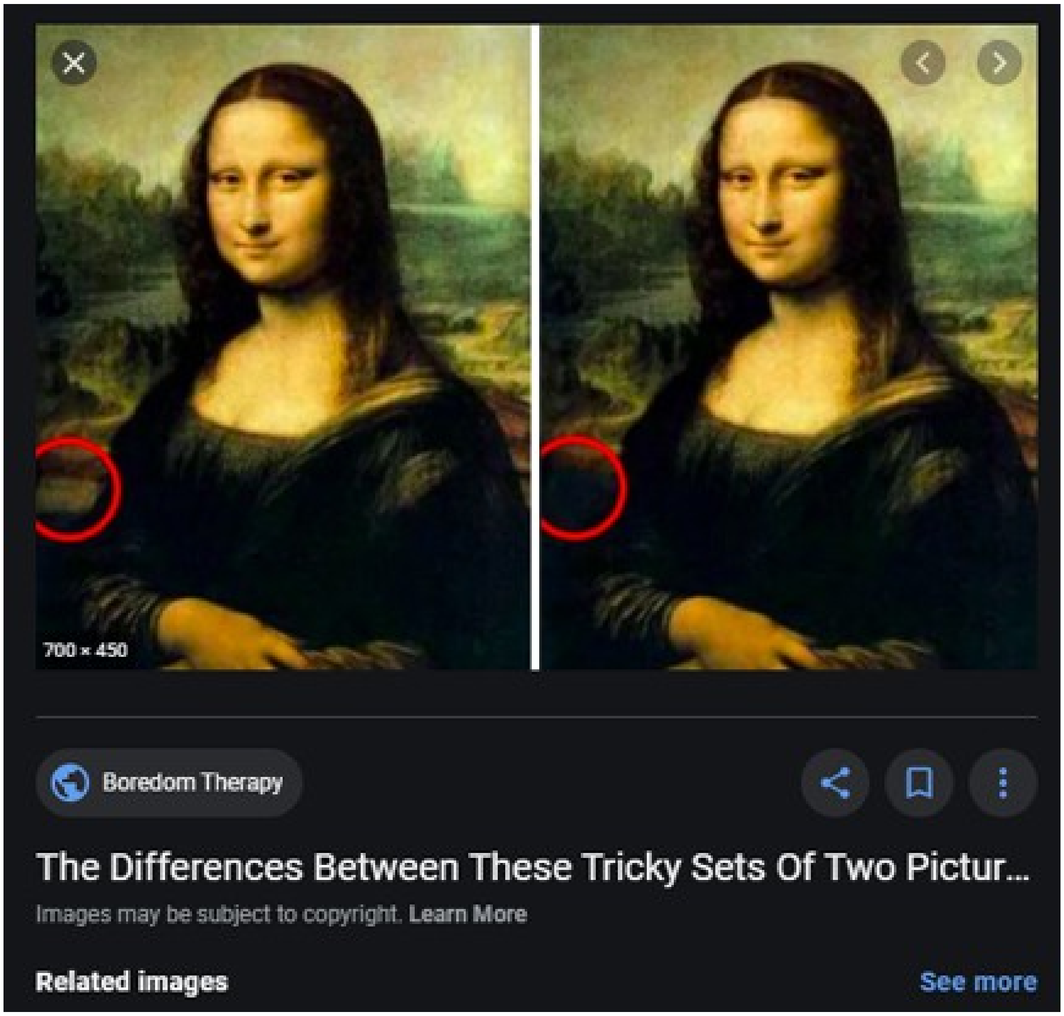
Again, my job in this paper is not to teach this drawing lesson stuff........

...or teach you how to draw **but impress upon you there is a whole other half-brain in your brain pretty much academically ignored** since about age 10 (about the time your 10 year old brain development really started to solidify around language) and certainly discounted almost in its entirety by higher education. (There's a quote by **Dr. Jerre Levy** commenting that it isn't as much higher education pretty much is, or has all but extinguished the right hemisphere's contribution, but caused her to comment only half jokingly is "out to destroy it" [42].

Even if you don't buy this proposal, or **doubt it could ever be incorporated** into an already over-crammed curriculum, the **visual recognition part of the Zeng approach** can be be extended in **this simple way** (much the way I saw a radiologist promote in a CT scan reading class) …."spot the difference".

Spot the difference

Go to Google. In "images" search "spot the difference". You'll get a bunch of the following types of photos and illustrations – or, **right now, go for it, try these samples - spot the difference**:



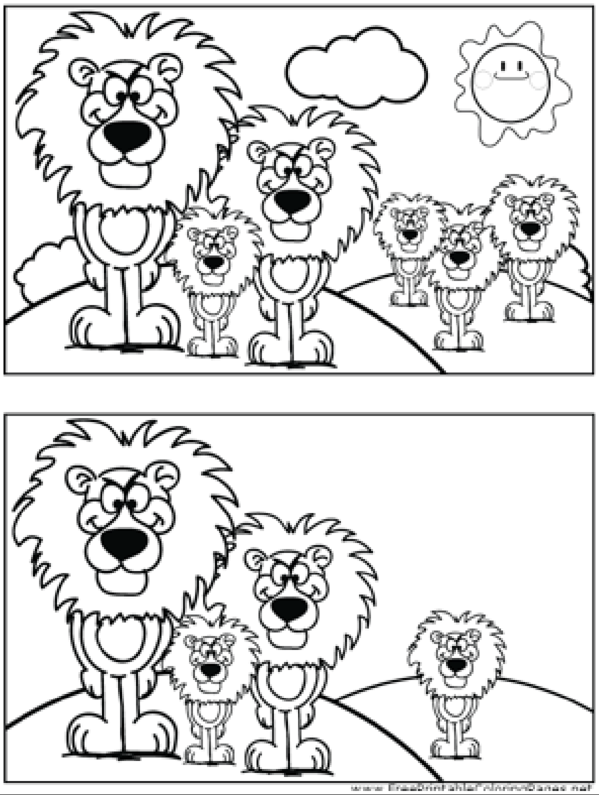
This one's a freebie

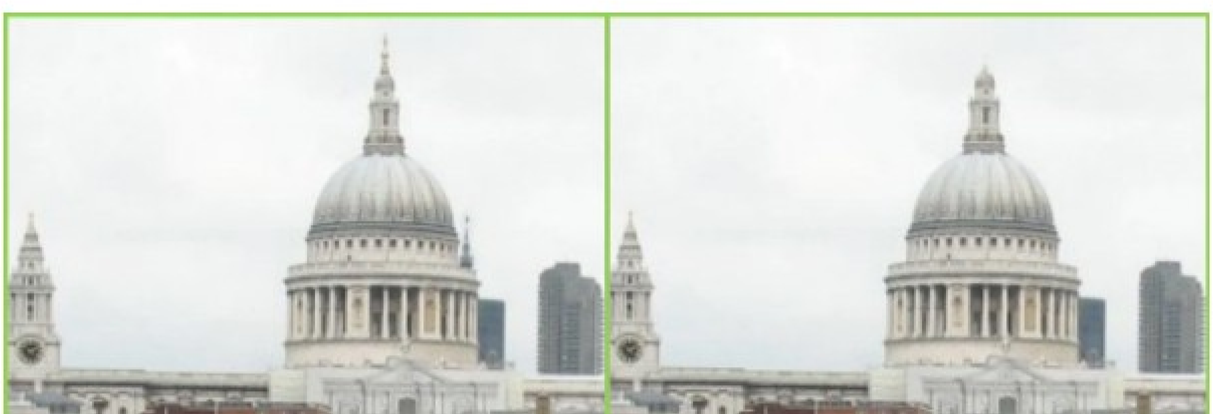
Try another – and don't look at the caption for the answer:

Top right side: little piece of salmon crossing the upper right margin. In fact, it's a photo-shopped copy of the salmon piece in the upper left half of the photo. How do I know it's a copy? Look at the little notch in the lowest part of the salmon. [There's also a piece of cheese missing on the left half along the bottom margin; there's a piece of cheese bottom third, just right of center with black specks erased...look at every little element in one picture and find it in the other; then go to the other side and find every little element in the opposite picture. Its a great observational workout. And Fun!] This is how you sharpen up.

And another – you're on your own:

Find the Differences

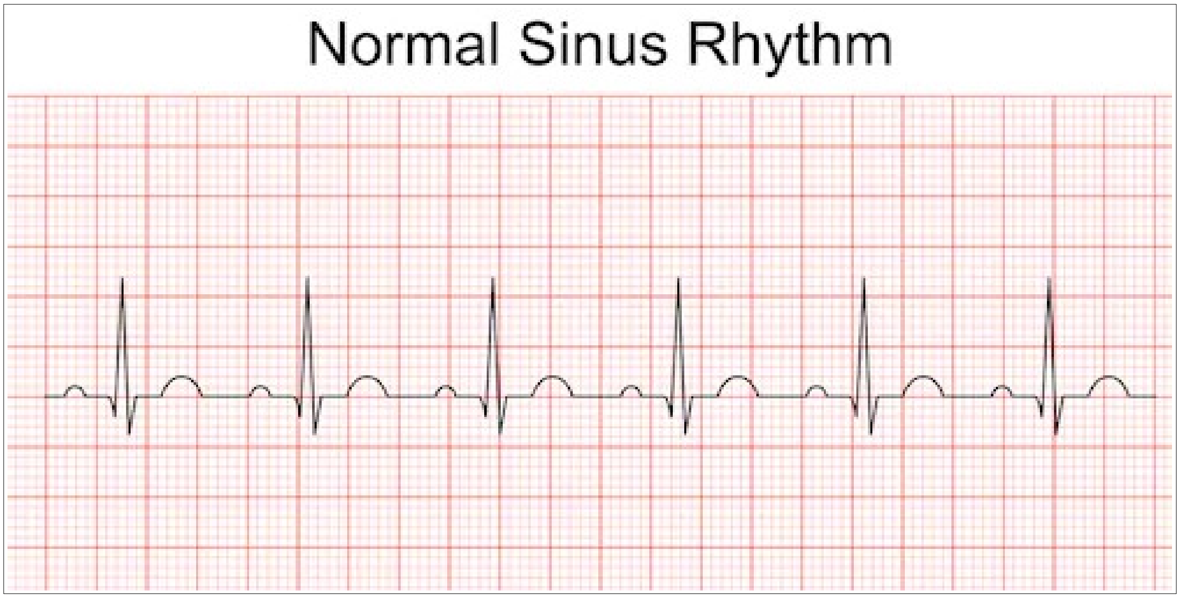




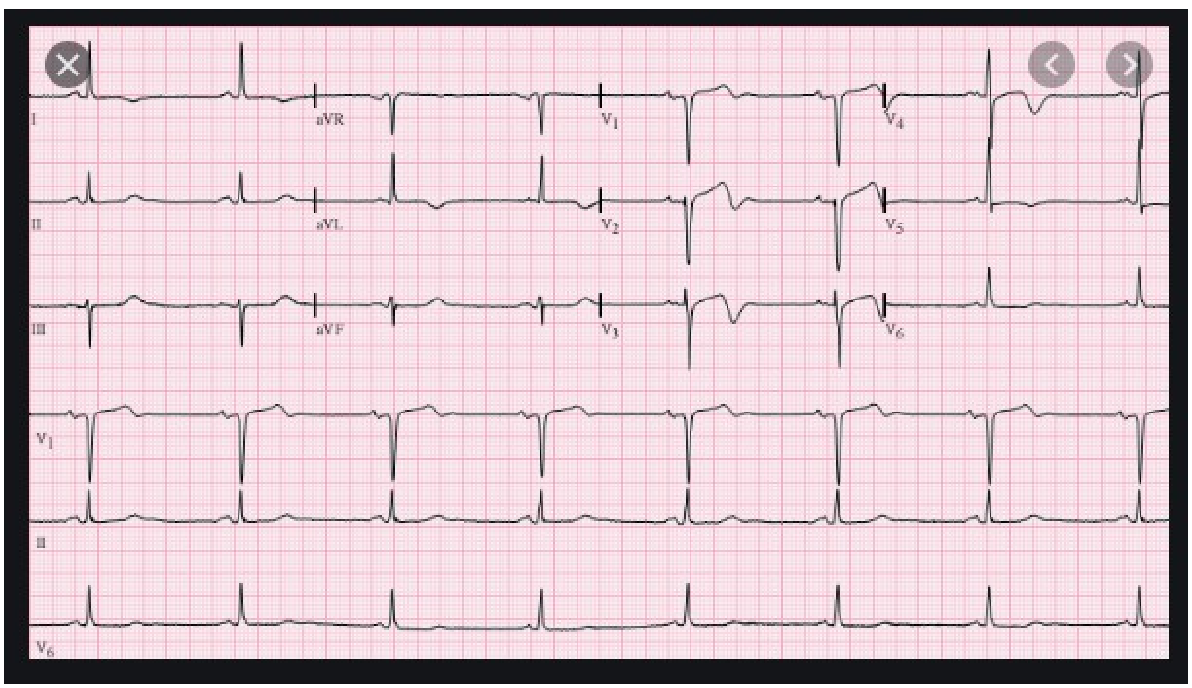
Hint: look at eyes, hat, overall buttons, and socks

You get the idea

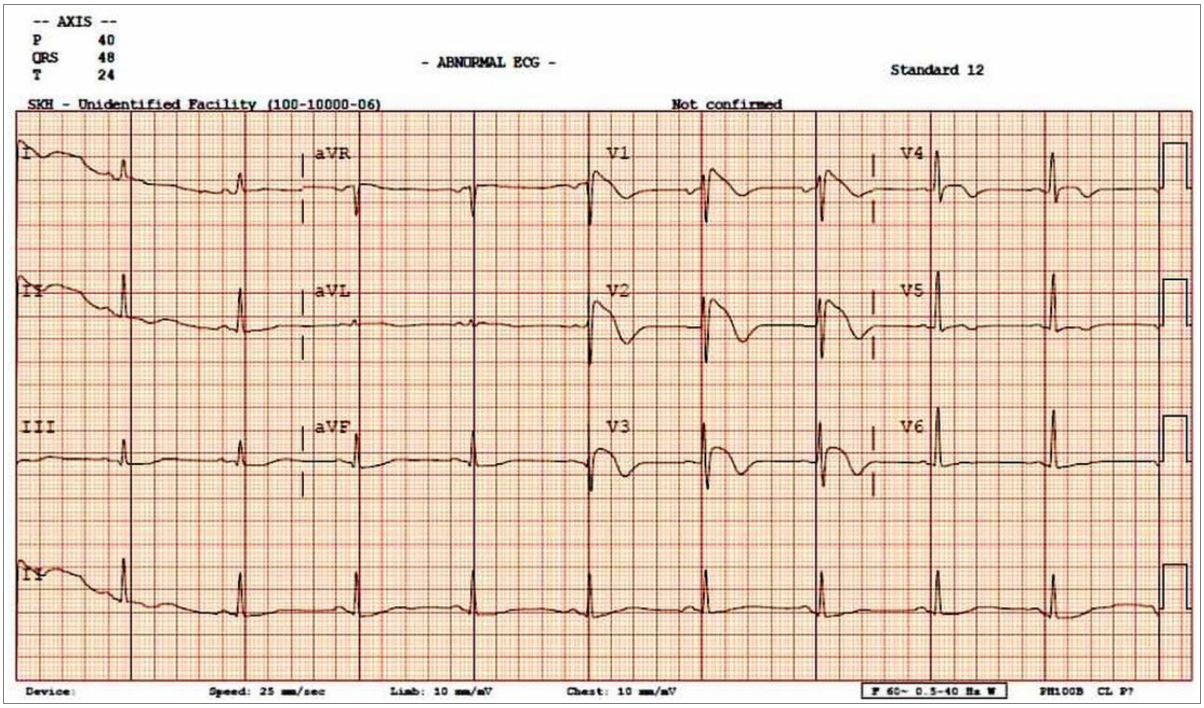
These are visual skill, R-mode exercises. Might seem silly. Not a lot of sophistication - but they work! Now when you see these, can you spot difference. Compare to the normal:



Compare:

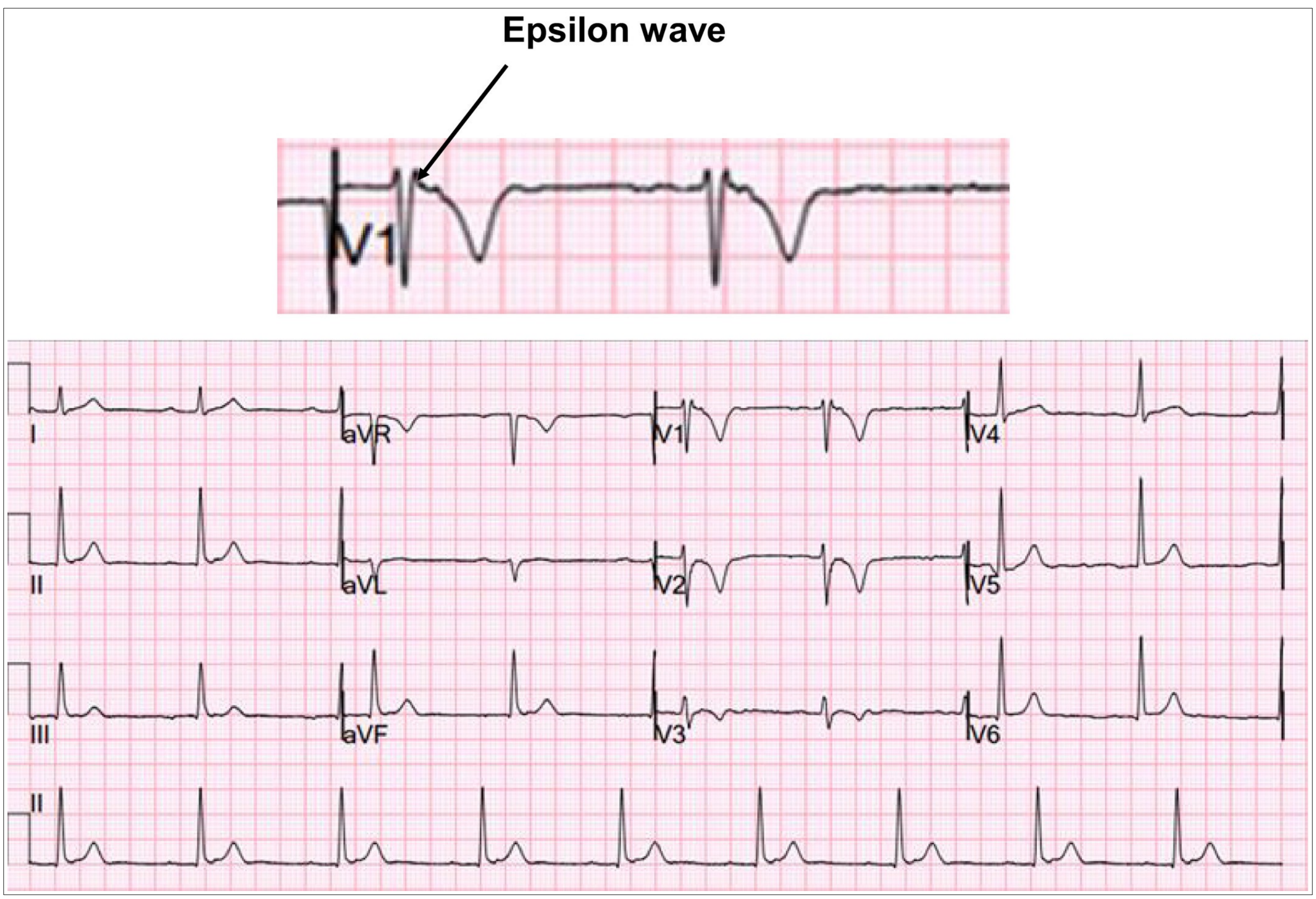


Suspicious for Wellens syndrome. How do you know?

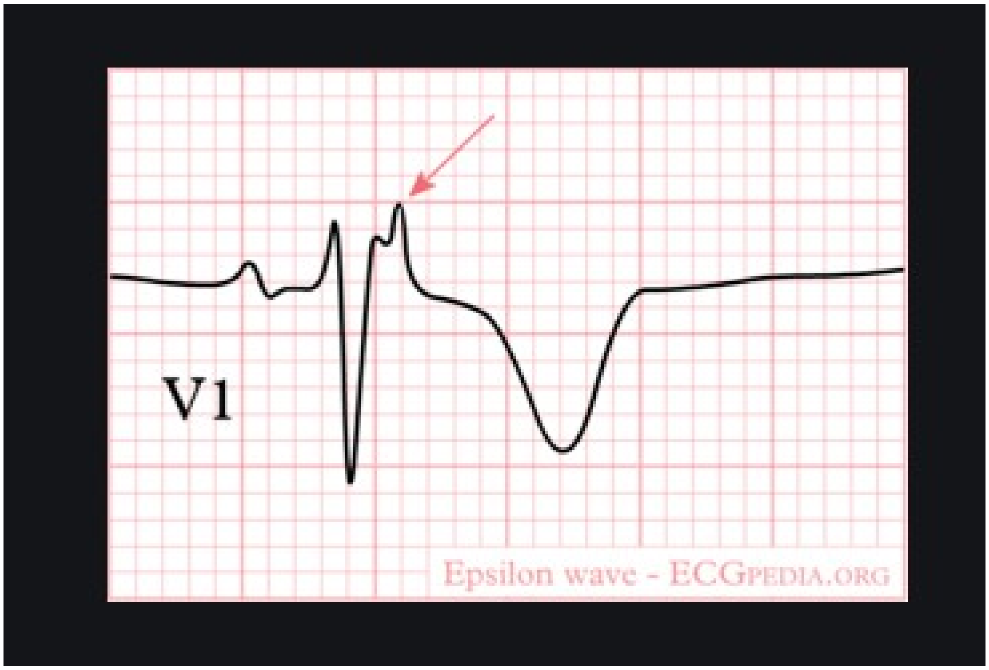


Sure looks like brug, bruga, err that Brugadas's thing?

Whats different between this tracing and the one directly above? Could it be the QRS width? The partial or incomplete bundle branch block? Or that ST (or lack of) ST segment?



Very subtle change in this one – best seen in anterior leads...but present all over the place...



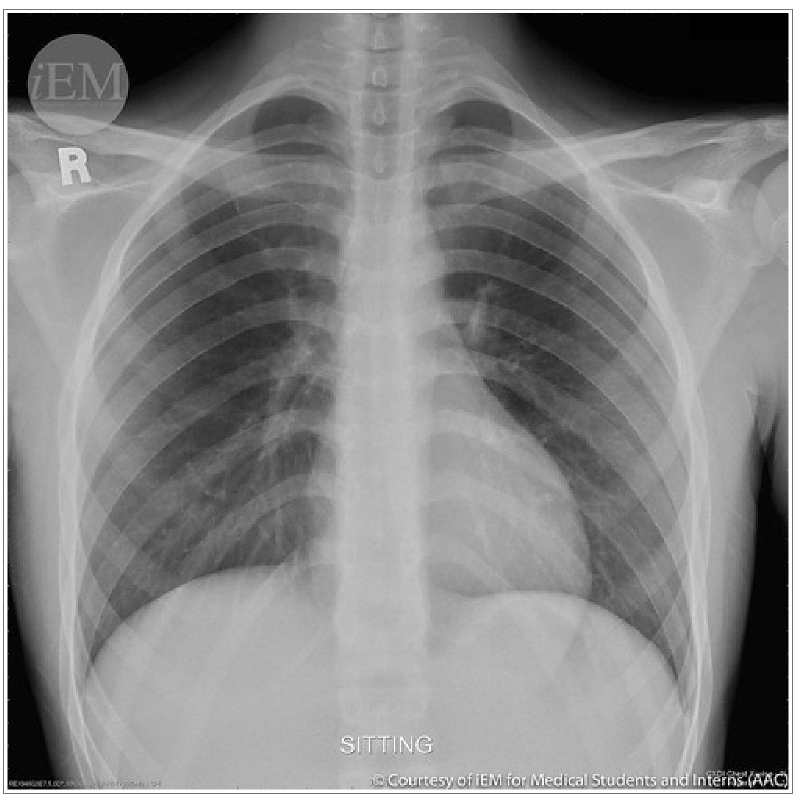
The three above: top: **Wellens** syndrome (the pinkish tracking)' **Brugadas** (the yellowish one); and Arrhythmogenic Right Ventricular Cardiomyopathy (**ARVC** - or formerly **ARVD** – the epsilon wave). All deadly. All commonly missed. **Can you tell them apart – and rapidly?** All easier spotted after a few runs through for example the **pure-contour exercise** (or after taking a run through learning to recognize the **horizontal landmarks** (using Ani Difranco as a model) of the face and reapply the techniques learned there to help decide how that *Brugada's* tracing differs from the *Wellens* syndrome - **e.g. deciding** how the **R** and **R'** in lead I and lead II to help decipher *what's above* the isoelectric baseline or *what's below it* – and maybe a little exposure again to recognizing angles and proportions – there's lots of exposure at this page. Or an exposure to profile drawings; again, **no need to learn to draw**, but **learn to look at things** - like ecg tracings and xrays, etc.

--- - ***with a whole new observational repertoire of interpretive skills***).

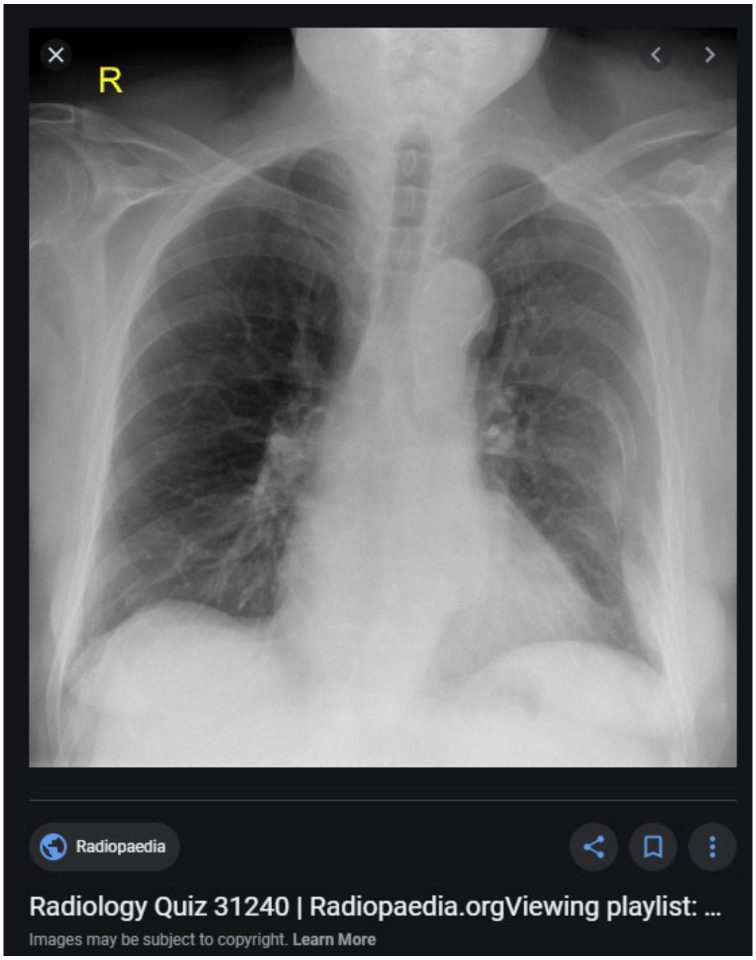
The pure-contour exercise linked above in an entry level DRSB drawing lesson context produced this kind of palm crease drawing:

Almost starts looking like an ECG. Ok, maybe that's a long shot.

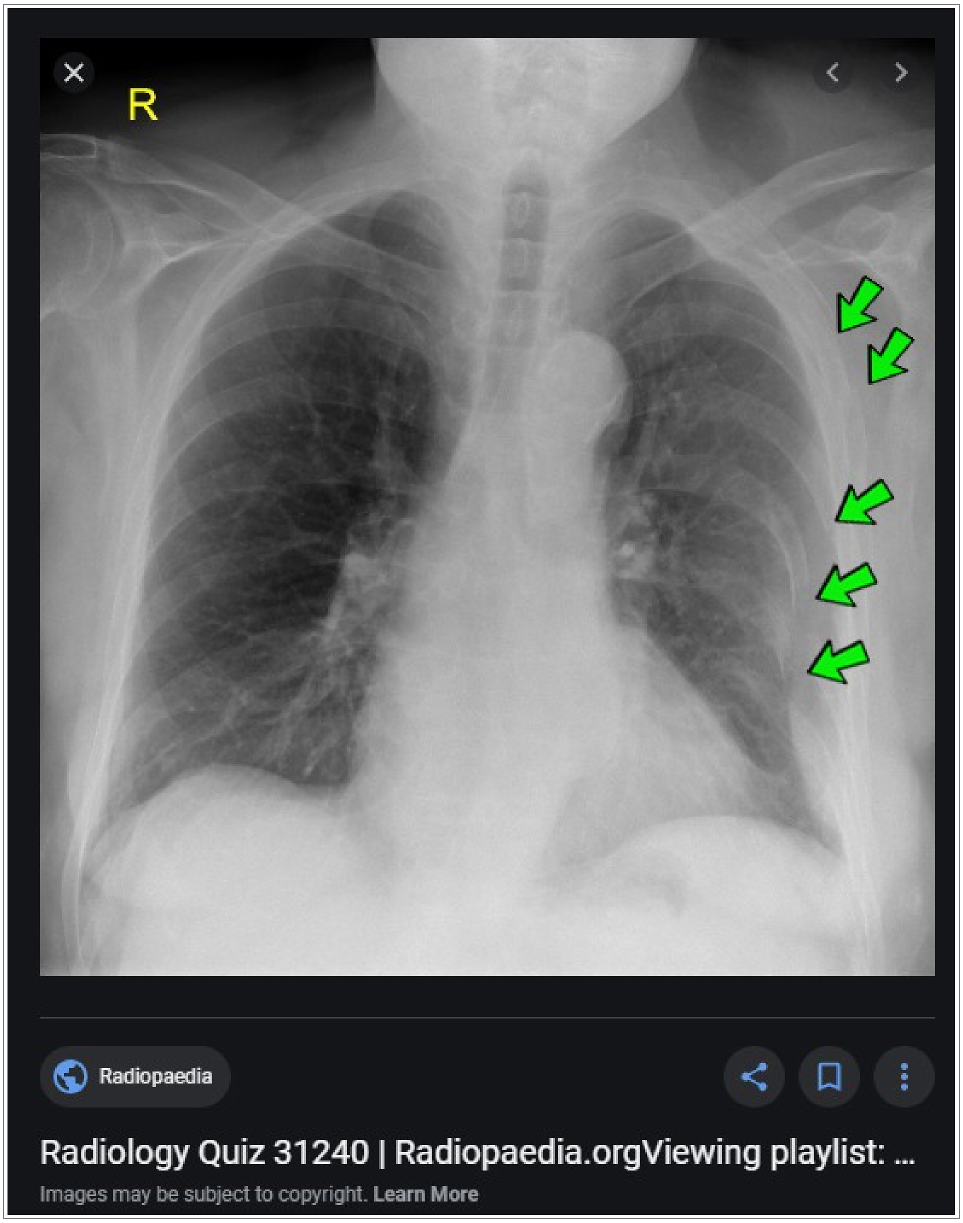
And take this a one last step. Here's a normal PA chest xray:



Go back and forth between this normal chest xray and the **next one just below**.
Can you spot differences?



Now for the answer....I apologize for the page breaks, a software glitch – but they may keep you from looking ahead :-).....



Missed them first try? Go back to the first chest xray and run your eye along EVERY margin of EVERY rib – just as if you were doing "pure-contour" drawing. (The pure contour lesson links are above.)

Again if you do nothing else, try these "can you spot the difference" type exercises as a a warm up ans a challenge. (Amazon has a whole library section on this : https://www.amazon.com/Games%C2%AE-Difference-Editors-Publications-International/dp/1680229362

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Conclusion

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We've seen the **ABIM's Cardiology** fellows' high bar of the **pure volume** of what could be known (eg the 94 required rhythms). We've seen how **different classroom approaches** – straight lecture versus small group, laboratory approaches yield different results. We've even seen non-classroom "on-your-own" **computer guided** classes yield at least the same results as the best lectures. We've seen the stick for the most part, (**summative** versus **formative**) produces better test scores. YET, not so fast (!) others have shown self-motivated student getting equivalent scores; **cramming** for tests always **leads** to **rapid loss of retention**. Without follow-up tests or some kind of repetition of skills (in anything) decay rapidly. **Use it or lose it** applies. Everywhere.

You saw mention above about the **eye-tracking experiments** on "successful ECG interpreters" – to discover what is it these successful readers of ECG's do? How do they use their eyes literally? To someone **with an artists training** this experiment only underscores the power of **observation** that **can be sharpened** – and that can benefit our roles as clinicians – as interpreters of ecg's of all sorts of imaging and even the face to face physical exam.

(In fact I read in awe to the degree of different numeric observations made by the authors of that article, all the different analytic moves they made to validate their findings – I just have to shake my head – almost shudder. With a little training in perceptive skills, they could skip all that. **Opinion**: it was an article better relegated to the **New England Journal of Ridiculous And Amazingly *OBVIOUS* Medicine**. Why waste the time? Just take some drawing lessons and ***learn how to observe*** using your own god given senses. Common senses at that.)

My goal in this paper

My goal in this paper is to **respect** what has been tested and what has been **proven to work** in helping students learn how to interpret ECGs (or xrays or any imaging). Professional schools in nursing or medicine, however in my opinion, through tradition and a predominantly **language-driven educational format** has forgotten or ignored or just never fully realized **visual skills *are different*.** They **need to be taught differently** and need to be, in my opinion, incorporated once again into our intellectual interpretive apparatus.

In the articles above There have been hints: one author promoted teaching ECG interpretation through a 3D model (**epicardio.com**) ; or **ECGSIM.com** – that he believes the disconnect between the ECG tracing and understanding actual conduction pathways in the heart might actually yield improved clinical accuracy. (I wrote my agreement and criticisms of that approach in that section.)

Or the professor (**Karen K Schultz**) who promoted the idea that dancing (disconnected from any ECG classes – just the act of dancing – which as a male, I hesitate at) improved ECG interpretation; or the hilarious video where the cardiologist (**Cardiologist John Grammer, MD, FACC**) danced out each rhythm, (which personally I loved), or the example employing the **squishy heart** while walking in front of a large projected tracing on the wall enacting and "feeling" each different electrical movement through the heart and coupled it with a contraction on **the “squishy heart”**.

All of these silly as they may seem, along with being different and maybe even fun, to me **betray a craving** and **a neglected propensity we all have** for something beyond the rote analytic, left-brained, left-hemispheric, language centered, L-mode we've pretty much funneled of higher ed in it's entirety. (The dancing approach all by itself gets you “out of your head” and into your body, which makes you more visually and kinesthetically aware and alert. No surprise that works!

Split brain research has shown now for 70 years, we're neglecting a huge part of our observational brain. These other approaches are testaments to that – even if they don't overtly state it, or if literally can't find the words to define it. **Betty Edwards in her DRSB approach**, as I've said more than enough times nails that entry point down. I ran through a crash course above of how I might approach this or incorporate these ideas in teaching an introductory ECG class.

So how to incorporate DRSB skills?

Every aspect of ECG interpretation and education is important: its a huge subject. Learning a small handful of drawing skills will not replace the eg knowing **the 94 rhythms** (see copy in appendix below) the **American Board of Internal Medicine** requires cardiologist to learn.

We all still have to learn the **clinical context** where pathologic ECGs can arise. You're not going to be spared memorizing a sizable handful (like 15 – 27 different rhythms) that many of the authors have underscored as the ones most needed to know for anyone claiming or yearning to be an urgent care or acute care or critical care practitioner. (I've colored those most commonly required rhythms in a background soft yellow highlight in the text above....just like this.)

Is repetition, repetition, repetition - really the key?

The tests and papers outlined above also show that even with the repetition (like 11,000 ECG's in 3 months) did not assure the clinician would make the accurate diagnosis when it was most needed. And repetition ***is key*** to becoming proficient at reading ECG's. **Zengs GSMM** approach showed some amazing results (if the results are to be believed).

But again it is my belief a sprinkling of the DRSB approaches repeated over time or for 10 minutes at the beginning of every few or even *every* ECG class, or at the other extreme taking a **5 to 6 day, 40 hour immersion course** (see the amazing results in drawing **here**) – to get into the brains “in-the-now”, observational , sense-oriented, spacial and visual reconnoitering R-mode, **in my opinion is the missing link in ECG education** – or for that matter ***any* of the imaging disciplines** and diagnostics we employ. Including the actual physical exam.

More on how to incorporate these skills?

How to incorporate these skills? – well that's going to have to wait until l I have the time and energy and the academic place to test out different approaches. But in my own online teaching experience I've seen the rapid results and the satisfied **fledgling artists** make pretty impressive progress. There's no reason medicine or medical education cannot benefit from even a small effort learning just a handful of the same.

Peace and happy (guarded) holidays!

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Appendix

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GENERAL FEATURES

- ☐ 1. Normal ECG
- ☐ 2. Borderline normal ECG or normal variant
- ☐ 3. Incorrect electrode placement
- ☐ 4. Artifact

P WAVE ABNORMALITIES

- ☐ 5. Right atrial abnormality/enlargement
- ☐ 6. Left atrial abnormality/enlargement

ATRIAL RHYTHMS

- ☐ 7. Sinus rhythm
- ☐ 8. Sinus arrhythmia
- ☐ 9. Sinus bradycardia (<60)
- ☐ 10. Sinus tachycardia (>100)
- ☐ 11. Sinus pause or arrest
- ☐ 12. Sinoatrial exit block
- ☐ 13. Atrial premature complexes
- ☐ 14. Atrial parasystole
- ☐ 15. Atrial tachycardia
- ☐ 16. Atrial tachycardia, multifocal
- ☐ 17. Supraventricular tachycardia
- ☐ 18. Atrial flutter
- ☐ 19. Atrial fibrillation

AV JUNCTIONAL RHYTHMS

- ☐ 20. AV junctional premature complexes
- ☐ 21. AV junctional escape complexes
- ☐ 22. AV junctional rhythm/tachycardia

VENTRICULAR RHYTHMS

- ☐ 23. Ventricular premature complex(es)
- ☐ 24. Ventricular parasystole
- ☐ 25. Ventricular tachycardia (3 or more consecutive complexes)
- ☐ 26. Accelerated idioventricular rhythm
- ☐ 27. Ventricular escape complexes or rhythm
- ☐ 28. Ventricular fibrillation

AV CONDUCTION

- ☐ 29. AV block, 1°
- ☐ 30. AV block, 2° — Mobitz type I (Wenckebach)
- ☐ 31. AV block, 2° — Mobitz type II
- ☐ 32. AV block, 2:1
- ☐ 33. AV block, 3°
- ☐ 34. Wolff-Parkinson-White pattern
- ☐ 35. AV dissociation

ABNORMALITIES OF QRS VOLTAGE OR AXIS

- ☐ 36. Low voltage
- ☐ 37. Left axis deviation (> – 30°)
- ☐ 38. Right axis deviation (>+100°)
- ☐ 39. Electrical alternans

VENTRICULAR HYPERTROPHY

- ☐ 40. Left ventricular hypertrophy
- ☐ 41. Right ventricular hypertrophy
- ☐ 42. Combined ventricular hypertrophy

INTRAVENTRICULAR CONDUCTION

- ☐ 43. RBBB, complete
- ☐ 44. RBBB, incomplete
- ☐ 45. Left anterior fascicular block
- ☐ 46. Left posterior fascicular block
- ☐ 47. LBBB, complete
- ☐ 48. LBBB, incomplete
- ☐ 49. Intraventricular conduction disturbance, nonspecific type
- ☐ 50. Functional (rate-related) aberrancy

Q WAVE MYOCARDIAL INFARCTION

	Age recent, or probably acute	Age indeterminate, or probably old
Anterolateral	☐ 51.	☐ 52.
Anterior or anteroseptal	☐ 53.	☐ 54.
Lateral	☐ 55.	☐ 56.
Inferior	☐ 57.	☐ 58.
Posterior	☐ 59.	☐ 60.

ST, T, U WAVE ABNORMALITIES

- ☐ 61. Normal variant, early repolarization
- ☐ 62. Normal variant, juvenile T waves
- ☐ 63. Nonspecific ST and/or T wave abnormalities
- ☐ 64. ST and/or T wave abnormalities suggesting myocardial ischemia
- ☐ 65. ST and/or T wave abnormalities suggesting myocardial injury
- ☐ 66. ST and/or T wave abnormalities suggesting electrolyte disturbances
- ☐ 67. ST and/or T wave abnormalities secondary to hypertrophy
- ☐ 68. Prolonged Q-T interval
- ☐ 69. Prominent U waves

CLINICAL DISORDERS

- ☐ 70. Digitalis effect
- ☐ 71. Digitalis toxicity
- ☐ 72. Antiarrhythmic drug effect
- ☐ 73. Antiarrhythmic drug toxicity
- ☐ 74. Hyperkalemia
- ☐ 75. Hypokalemia
- ☐ 76. Hypercalcemia
- ☐ 77. Hypocalcemia
- ☐ 78. Atrial septal defect, secundum
- ☐ 79. Atrial septal defect, primum
- ☐ 80. Dextrocardia, mirror image
- ☐ 81. Chronic lung disease
- ☐ 82. Acute cor pulmonale including pulmonary embolus
- ☐ 83. Pericardial effusion
- ☐ 84. Acute pericarditis
- ☐ 85. Hypertrophic cardiomyopathy
- ☐ 86. Central nervous system disorder
- ☐ 87. Myxedema
- ☐ 88. Hypothermia
- ☐ 89. Sick sinus syndrome

PACEMAKER FUNCTION

- ☐ 90. Atrial or coronary sinus pacing
- ☐ 91. Ventricular demand pacemaker (VVI), normally functioning
- ☐ 92. Dual-chamber pacemaker (DDD), normally functioning
- ☐ 93. Pacemaker malfunction, not constantly capturing (atrium or ventricle)
- ☐ 94. Pacemaker malfunction, not constantly sensing (atrium or ventricle)

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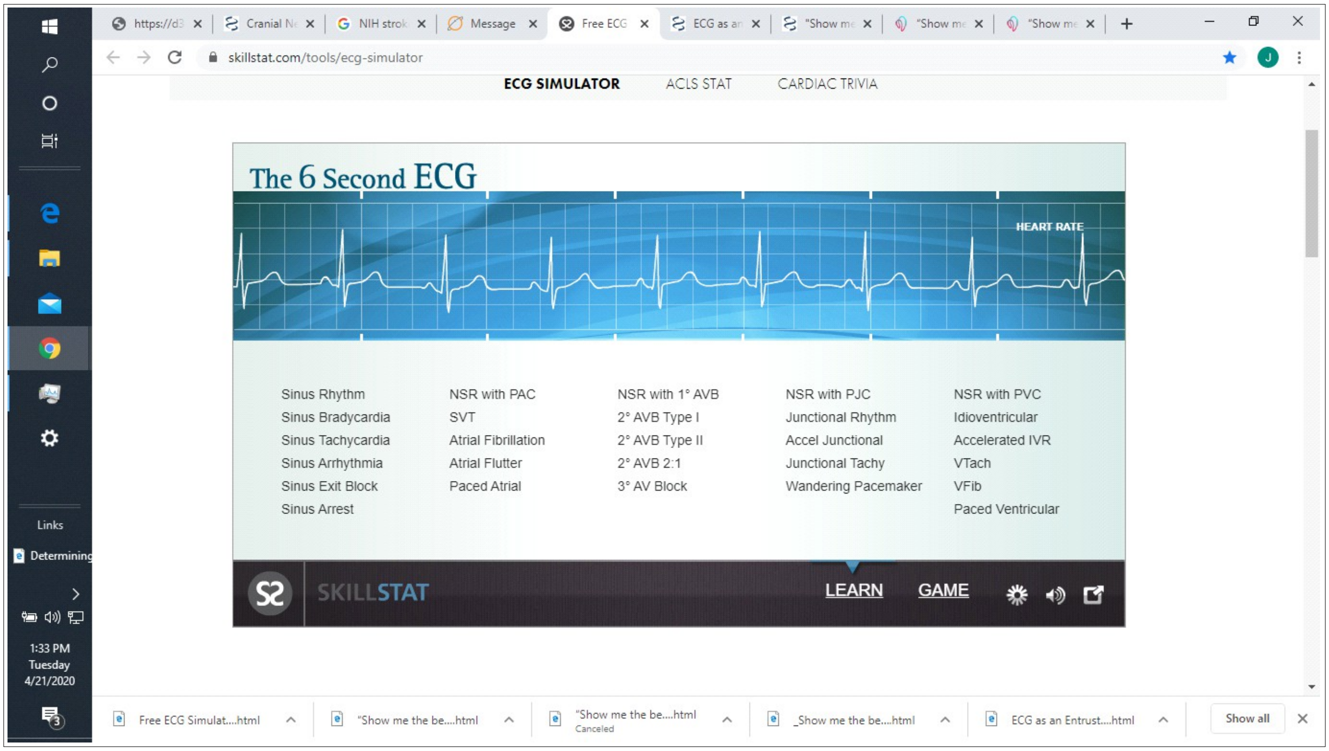
Illustration 1: ABIM 94 ecg question answer sheet as used by Cardiology Fellowship Programs

Illustration 2 : Smaller more limited ecg recognition goals: the 27 ecg list:



Drawing on the Right Side of the Brain Teaching Certification Diploma:

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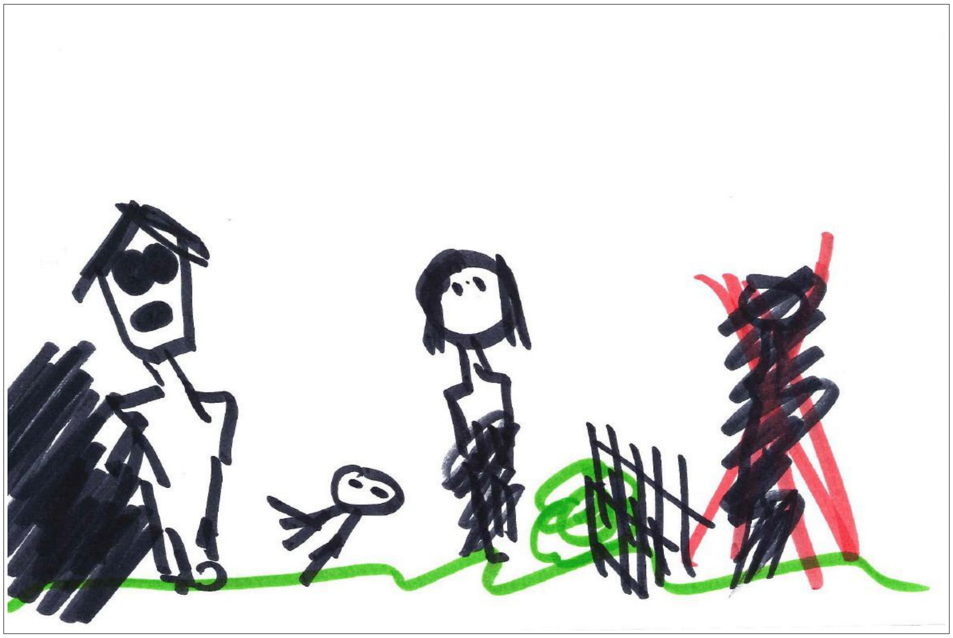
30) – Louis Bolks book on comparative anatomy: cerebral growth, and the necessary extended period to allow for its growth - about 3/4ths the way down this page the observation of the preponderance of the neo cortex (gray matter) in humans and the correlation of the seventh month to fetal chimp in utero development matches the 9th month of human development – underdeveloped compared to ape, and completely unprepared to fend for itself.
https://tomvangelder.antrovista.com/man-and-the-chimpanzee-164m83.html

31) Michael S. Gazzaniga - Groundbreaking work that began more than a quarter of a century ago has led to ongoing insights about brain organization and consciousness – **The Split Brain Revisited**
https://personal.utdallas.edu/~otoole/CGS2301_S09/7_split_brain.pdf

32) From “What kids drawings reveal about their homes”
[see https://www.thecut.com/2014/12/what-kids-drawings-reveal-about-their-homes.html]



33) *Homo erectus* - A Bigger, Smarter, Faster Hominin Lineage
https://www.nature.com/scitable/knowledge/library/homo-erectus-a-bigger-smarter-97879043/

34) ROGER WOLCOTT SPERRY August 20, 1913-April 17, 1994, BY THEODORE J. VONEIDA
"WHERE DOES behavior come from? What is the purpose of consciousness?"
See especially p. 322, use your browser "find" function, search "learn" in browser, go to #4/6
https://www.nap.edu/read/5737/chapter/17#321

35) Split-brain – General overview
https://en.wikipedia.org/wiki/Split-brain

36) The Unity of Consciousness and the Split-Brain Syndrome, Tim Bayne
The Journal of Philosophy
Vol. 105, No. 6 (Jun., 2008), pp. 277-300 (24 pages)
Published By: Journal of Philosophy, Inc.
https://www.jstor.org/stable/20620103?seq=1

37) Jerre Levy **Cerebral asymmetries as manifested in split-brain man**
great source of related papers here also:
https://philpapers.org/rec/LEVCAA-6

38) Philip D. Harvey**, PhD, Domains of cognition and their assessment**
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6829170/

39) Emotional Development - Self and Self-Conscious Emotions
https://rwjms.rutgers.edu/departments/pediatrics/divisions/institute-for-the-study-of-child-development/research/emotional-development#:~:text=Shame%2C%20Pride%2C%20and%20Embarrassment,and%2024%20months%20of%20age.

40) Jackie Sturt, PhD, Neurolinguistic programming: a systematic review of the effects on health outcomes
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3481516/

41) The Six-Step Method for 12-Lead ECG Interpretation
JANUARY 25, 2010 | 12 LEAD ECG | TOM BOUTHILLET |

http://ems12lead.com/2010/01/25/the-six-step-method-for-12-lead-ecg-interpretation/

42) Jerre Levy Ph. D. quote – use your browser's find function - see instance 5/6 for "jerre" at link below;
"But the emphasis of our culture is so strongly slanted toward rewarding left-brain skills that we are surely losing a very large proportion of the potential ability of the other halves of our children's brains. Scientist Jerre Levy has said— only partly humorously— that American scientific training through graduate school may entirely destroy the right hemisphere."
http://www.ingetang.com/praxis/anewdrawing/3-right-side-your-brain-the-right-and-left-of-it/

43) More reading: https://jamanetwork.com/journals/jamainternalmedicine/article-abstract/2771093?utm_campaign=articlePDF%26utm_medium%3darticlePDFlink%26utm_source%3darticlePDF%26utm_content%3djamainternmed.2020.3989

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Other Resources:

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Maven ECG online:

https://ecg.bidmc.harvard.edu/maven/mavenmain.asp
https://www.facebook.com/EcgWaveMaven/

Letter Written to Dr. Karen Shultz:

Author: Karen K. Schultz, PhD, MBA, Associate Professor, Instruction Design and Pharmacy Practice,

September 22, 2020

Dear Dr Schultz,

HI, my name is Jeff Kasbohm, PA-C, I've been an emergency / urgent care PA since 1992, I stumbled across your paper while writing (as I write) my capstone project for the MPAS program (Masters of Physician Assistant Studies) affiliated with Touro University out of New York City (online program).

The gist of my paper is about using and incorporating drawing skills as taught in Dr Betty Edwards hugely successful book **Drawing on the Right Side of the The Brain** (DRSB). Being a certified instructor of the DRSB methods used in her book, and being in the branch of medicine I am (ie reading, interpreting and acting upon ECG's), I have a little extra qualification to being dong this :-) (You can see my license at the my "**YouCanDraw.com**" homepage -- a site I started 24 years ago.

Anyway, the premise for the paper is -- since like reading xrays -- reading ECG's is a *visual* skill, then why not expose students to the simple - yet breakthrough methods - Dr Edwards teaches in her book?

In doing the research -- building a case for non-conventional ways of learning ECG -- **I stumbled upon your paper:**

Teaching Electrocardiogram Basics Using Dance and Movement
Karen K. Schultz, PhD, MBA and Marcia L. Brackbill, PharmD
https://pubmed.ncbi.nlm.nih.gov/19657503/

Fascinating! Anyway to make a long story short, I have to ask you, if in the interaction between dance instructors and students might have any of the dances started to approach the types of representational dances that **Dr John Grammer** came up with decades ago -- like you can see in this YouTube video demonstrating cardiac arrhythmias and physical depictions:

https://www.youtube.com/watch?v=TJR2AfxVHsM

Its an hilarious video -- yet is absolutely accurate! I would be fascinated to know and will put your response in the paper (with your permission of course).

We all know the dire consequences of so many who're expected to be able read ECGs well (but really cannot) and with the increasing stress of larger and larger amounts of info to digest, alternative approaches may (but maybe not) make some positive contribution. That's my aim any way -- to find out :-)

You're busy, I'm busy, I'm just dashing this email off -- if any questions about sincerity you could call or text me at **952.738.2631** or just email me back at the address above (texting works much better - - I have the phone message recorder turned off ... too many "phishing" calls... I know you understand.)

Warmly, and hope to hear back!

Jeffrey O Kasbohm, PAC, (MPAS -- soon to be)
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952.738.0657