

### SI-PL-3004 - Special Interest Abstract

MODALITY AND DOSE DEPENDENCY IN ELECTROTHERAPY. Tim Watson;University of Hertfordshire, Hatfield, UK

**PURPOSE:** Models of electrotherapy suggest that the effects of electrotherapy interventions would be both modality and dose dependent. A significant number of papers that are published in all areas of electrotherapy appear to provide evidence of 'no effect' whilst others appear to provide evidence of significant efficacy. The 'negative' outcomes are often cited as evidence that electrotherapy is ineffective, or at best, just a placebo intervention. The purpose of this exercise was to identify whether there was any substantive evidence of modality or dose dependency in electrotherapy, and if so, to evaluate its potential impact on clinical practice.

**RELEVANCE:** Electrotherapy is used less frequently in practice than appears to have been the case historically. This change in emphasis is often said to be related to the apparent lack of research evidence in electrotherapy. There is in fact, no lack of evidence, but apparent conflicts within that body of evidence which may give rise to confusion. This analysis and proposed model of dependent therapeutic effects would help to clarify the clinical position and to provide a framework for researchers in this specialist field

**DESCRIPTION:** Using an extensive database of electrotherapy related research, the evidence for (a) modality specific effects and (b) dose dependent effects was evaluated. Evidence from a range of modalities including electrical stimulation, therapeutic ultrasound, low level laser and both pulsed and continuous shortwave therapies was considered. Research that identified 'no effect' of intervention was compared with work that provided evidence of significant benefit or change. Published papers employing a similar intervention but with different treatment parameters (dose) were particularly carefully considered. Some dose and treatment parameter mapping was undertaken to see if dose clustering was evident. **EVALUATION:** The evidence generated and models that were derived as a result of this work support the contention that there is a modality and dose dependent relationship in electrotherapy. This is, to some extent at least, predictable, as it is found in almost all areas of healthcare practice. The model of Therapeutic Windows, previously identified by the author has been expanded as a result.

**CONCLUSIONS:** It is concluded that a modality and dose dependent relationship for electrotherapy application exists. The same modality applied at a different dose may have greater or lesser effect on patients. Published research that does not demonstrate 'benefit' is not negative, in that it effectively helps to demonstrate where the therapeutic window is not, rather than demonstrating that the intervention is ineffective.

**IMPLICATIONS:** It is proposed that when applied at an 'effective' dose, electrophysical agents do have the capacity to achieve significant therapeutic benefit, beyond a placebo effect. When the same modalities are delivered at the 'wrong' dose, it is not surprising that their clinical effect is minimal or absent. The implication for practice focuses on the fact that negative outcomes alone do not justify the dismissal of a modality. It is the combined profile of the total research publications in a field that should inform practice. For researchers, this model may provide a tool by which future investigations can be focussed.

**KEYWORDS:** Electrotherapy  
Therapeutic Window  
Dose Dependency

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## Modality and Dose Dependency In Electrotherapy WCPT Vancouver 2007



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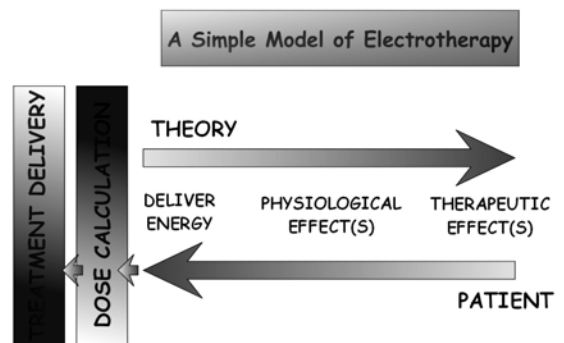
## Scope of Presentation

- ☆ Basic model of electrotherapy action
- ☆ Concept of Windows of Opportunity in Electrotherapy
- ☆ Examples of Dose Dependency related to the A-S Law / Model
- ☆ Example of therapeutic dose clusters
- ☆ Implications and Conclusion

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## Basic Model of Electrotherapy Action

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## Concept of Windows of Opportunity in Electrotherapy

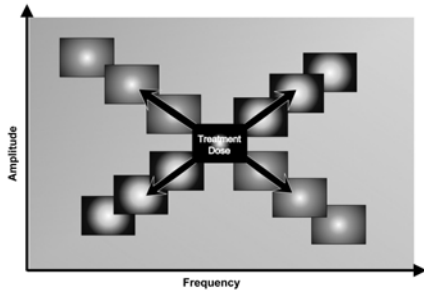
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## Electrotherapeutic Windows

- ☆ Amplitude window  
e.g. Litovitz 1990, Goldman 1996
- ☆ Frequency window  
e.g. Cleary 1987, Goldman 1996
- ☆ Strong contention for Energy window  
e.g. Watson 2000, Hill et al 2002
- ☆ All are DYNAMIC

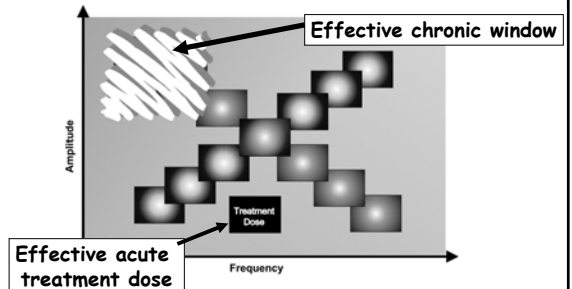
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### Example of an Amplitude and Frequency Window (Watson, 2000; 2002, 2006)



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### Using an 'Acute Window' to treat a Chronic problem



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### Treatment Issues in Relation to Windows and Tissue State

- ☆ The window position appears to move in relation to the tissue state / sensitivity
- ☆ Need to employ the appropriate modality for the target tissue
- ☆ Numerous ways in which to achieve an ineffective combination, even if one or more parameters are 'right'

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### Research Examples of Windows

- |                        |                       |
|------------------------|-----------------------|
| ☆ TENS - FREQUENCY     | ☆ US - FREQUENCY      |
| ☆ Hamza et al 1999     | ☆ Fabrizio et al 1996 |
| ☆ Han et al 1991       | ☆ Young & Dyson 1990  |
| ☆ Kararmaz et al 2004  | ☆ US - AMPLITUDE      |
| ☆ Palmer & Martin 1999 | ☆ Kramer 1987         |
| ☆ Sluka et al 2005     | ☆ Larsen et al 2005   |
| ☆ Walsh 1995           | ☆ Miller & Gies 1998  |
| ☆ TENS AMPLITUDE       | ☆ Reher et al 1997    |
| ☆ Chakour et al 2000   | ☆ Reher et al 2002    |
| ☆ Cramp et al 2002     | ☆ Schafer et al 2005  |

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- |                      |                        |
|----------------------|------------------------|
| ☆ LASER - AMPLITUDE  | ☆ PSWD / RF AMPLITUDE  |
| ☆ Pereira et al 2002 | ☆ Cleary 1987          |
| ☆ Karu 1987          | ☆ Frey 1974            |
| ☆ Shields et al 1993 | ☆ Hill et al 2002      |
| ☆ Tuner & Hode 2002  | ☆ Litovitz et al 1990  |
| ☆ Vinck et al 2003   | ☆ Takashima et al 2006 |

- |                      |                       |
|----------------------|-----------------------|
| ☆ LASER - MODULATION | ☆ PSWD / RF FREQUENCY |
| ☆ Martin et al 1991  | ☆ Cleary 1987         |

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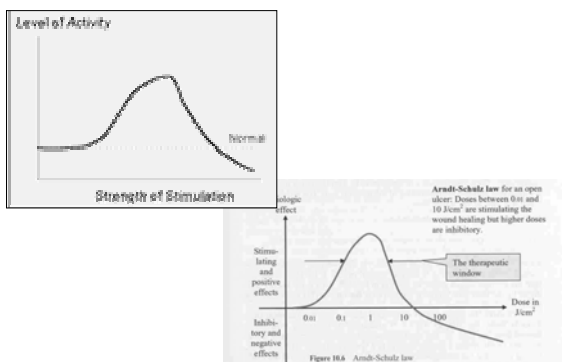
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|------------------------------|-----------------------|
| ☆ INTERFERENTIAL - FREQUENCY | ☆ ELEC STIM AMPLITUDE |
| ☆ Noble et al 2000           | ☆ Turler et al 2000   |
| ☆ Sontag 2000                | ☆ Lundberg et al 1989 |
| ☆ Lamb & Mani 1994           | ☆ ELEC STIM FREQUENCY |
| ☆ INTERFERENTIAL MODE        | ☆ McDowell et al 1999 |
| ☆ Johnson & Wilson 1997      | ☆ Takata & Ikata 2001 |

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## Examples of Dose Dependency related to the A-S Law and Model

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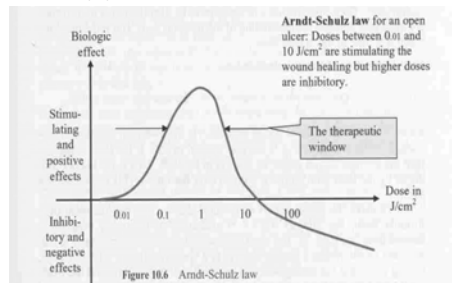
## Arndt-Schulz Law Representation



Arndt-Schulz rule or Schulz' law is a law (named after Hugo Schulz and Rudolf Arndt) concerning the effects of pharmaca or poisons in low, respectively strong concentrations. According to this, highly diluted pharmaca or poisons enhance life processes, moderately strong ones favour it, while strong concentrations may inhibit these processes and even terminate them. (Wikipedia, 2007)

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## Arndt-Schulz Law applied to Laser Therapy (after Tuner and Hode, 2004)



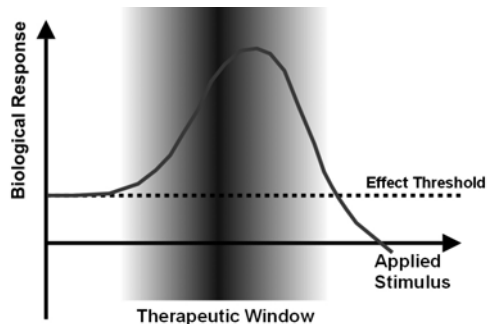
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## Combining Therapeutic Windows and the Arndt-Schulz Law

- ☆ Both principles are effectively looking at the same issues (but using different terminology)
- ☆ The A-S Law however is unidimensional in its typical presentation, whereas in fact, suggested that it is multidimensional

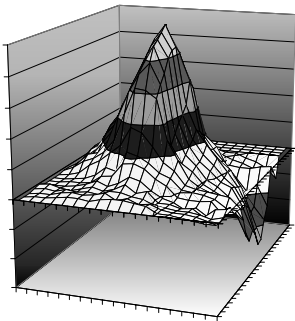
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## AS Law Essential Components



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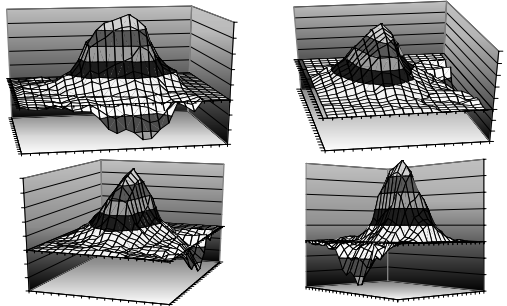
## Multidimensional AS Models



The commonly cited AS Curve only considers a single dimension whereas in reality a multi-dimensional construction is likely to be more representative

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## Multidimensional AS Models

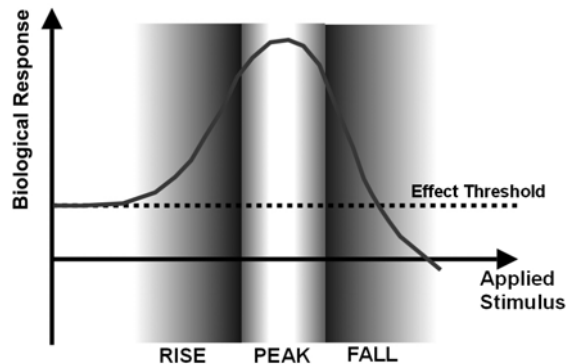


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## Variations on the AS 'Curve' Theme

- ☆ If one consider the AS curve in 3 sections (RISE / PEAK / FALL)
- ☆ 3 variations on RISE and FALL plus 2 variations of PEAK (very basic)
- ☆ End up with 18 basic curves for a UNIDIMENSIONAL consideration (say FREQUENCY)

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## Variations on the AS 'Curve' Theme

- ☆ If use same basic curve phases but consider 2 VARIABLES (say FREQUENCY and AMPLITUDE) get a minimum of 324 curves
- ☆ And with 3 VARIABLES : (FREQUENCY, AMPLITUDE and TIME)
- ☆ Get almost 6000 curve variations
- ☆ The REALITY is COMPLEX including the probability of BIMODAL CURVES

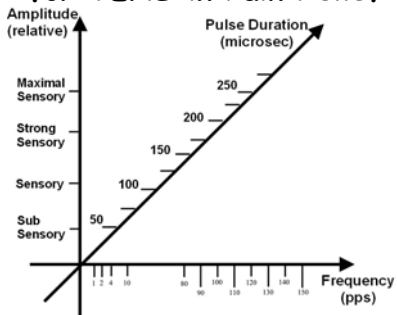
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## Plotting Effective Treatment Doses

- ☆ Ongoing task to look at published research evidence and link to THERAPEUTIC WINDOWS and variations in the AS Curves
- ☆ Many more ways of getting the dose 'wrong' than 'right'
- ☆ 'Negative' research findings help to identify where the window(s) are NOT rather than demonstrating that the modality is not effective

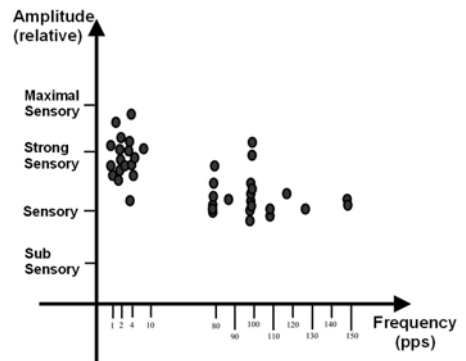
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## Example of Simple Windows Plot for TENS in Pain Relief

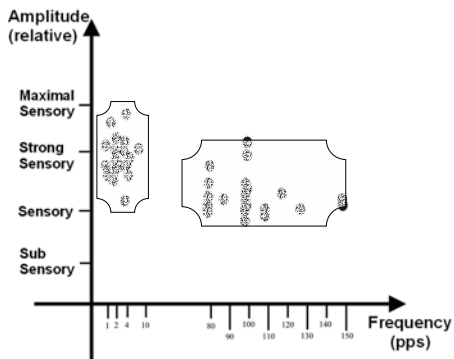


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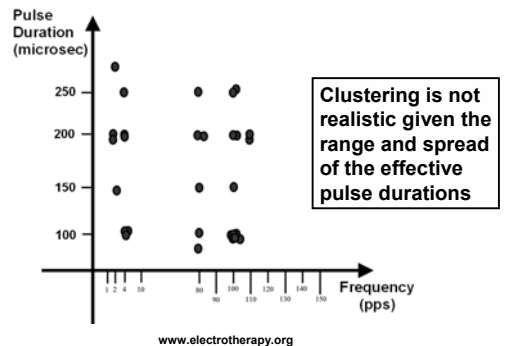
## Looking at Pulse Frequency



## Pulse Frequency Clusters



## Looking at Pulse Frequency combined with Pulse Duration



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## Conclusion

- ☆ A simple model of electrotherapy shows that the application of energy to the body has the capacity to influence cellular and tissue behaviour
- ☆ The effects of intervention appear to be both MODALITY and DOSE dependent

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- ☆ Therapeutic windows and the Arndt-Schulz Law are different ways of looking at the same issue
- ☆ The models currently proposed are (probably) over simplistic
- ☆ Many variations appear to be possible though clusters imply a limited number of sub-sets are likely to be most effective

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☆Research evidence that demonstrates 'no effect' is not negative as such but in fact helps to identify window location and curve peaks

☆Full analysis is ongoing and representation of variables in both a tabular and graphical format is proposed

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**Thank you**

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