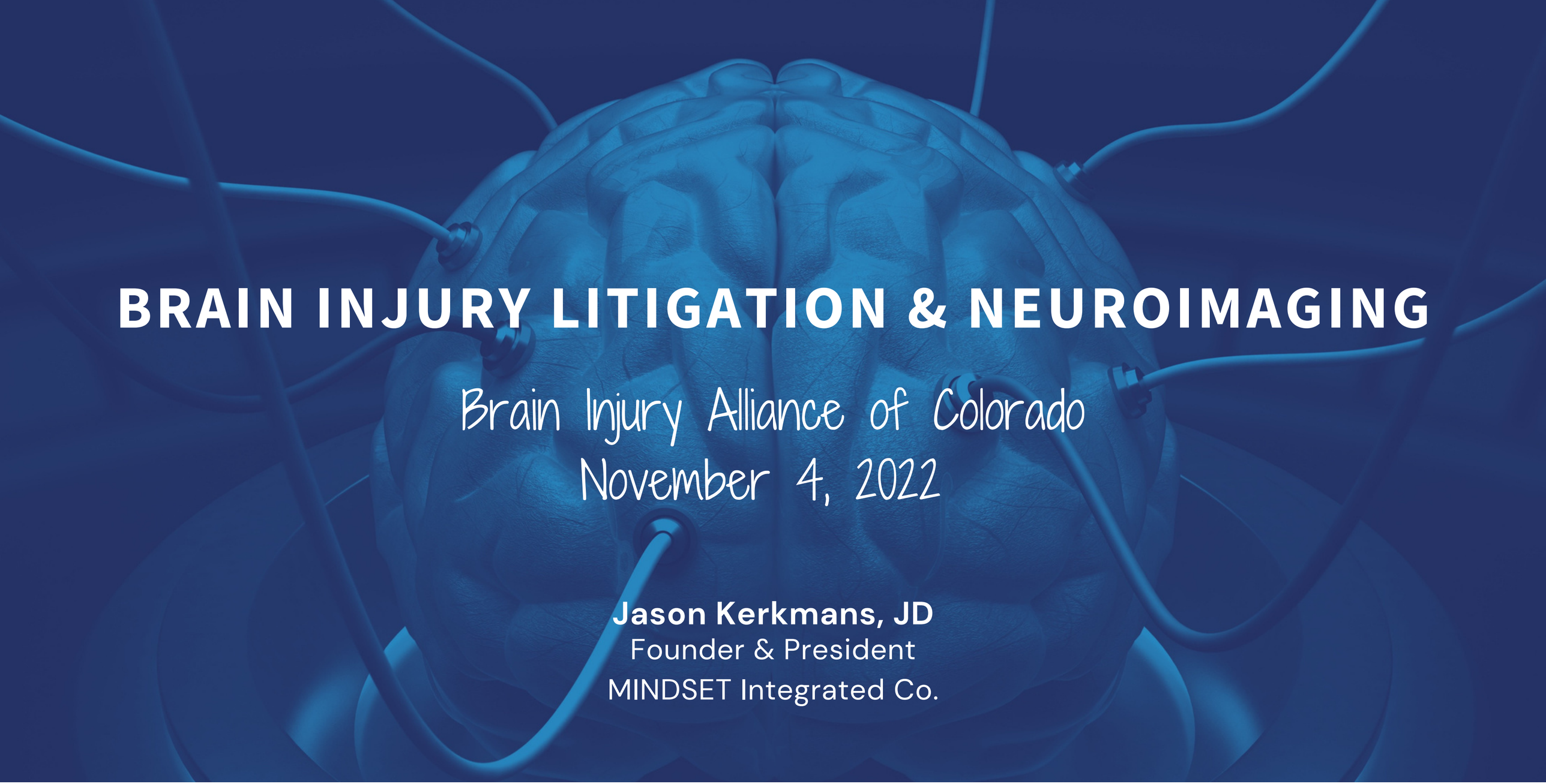


BRAIN INJURY LITIGATION & NEUROIMAGING

Brain Injury Alliance of Colorado
November 4, 2022

Jason Kerkmans, JD
Founder & President
MINDSET Integrated Co.

Roadmap

For our neuroscience & law journey

Neuroscience

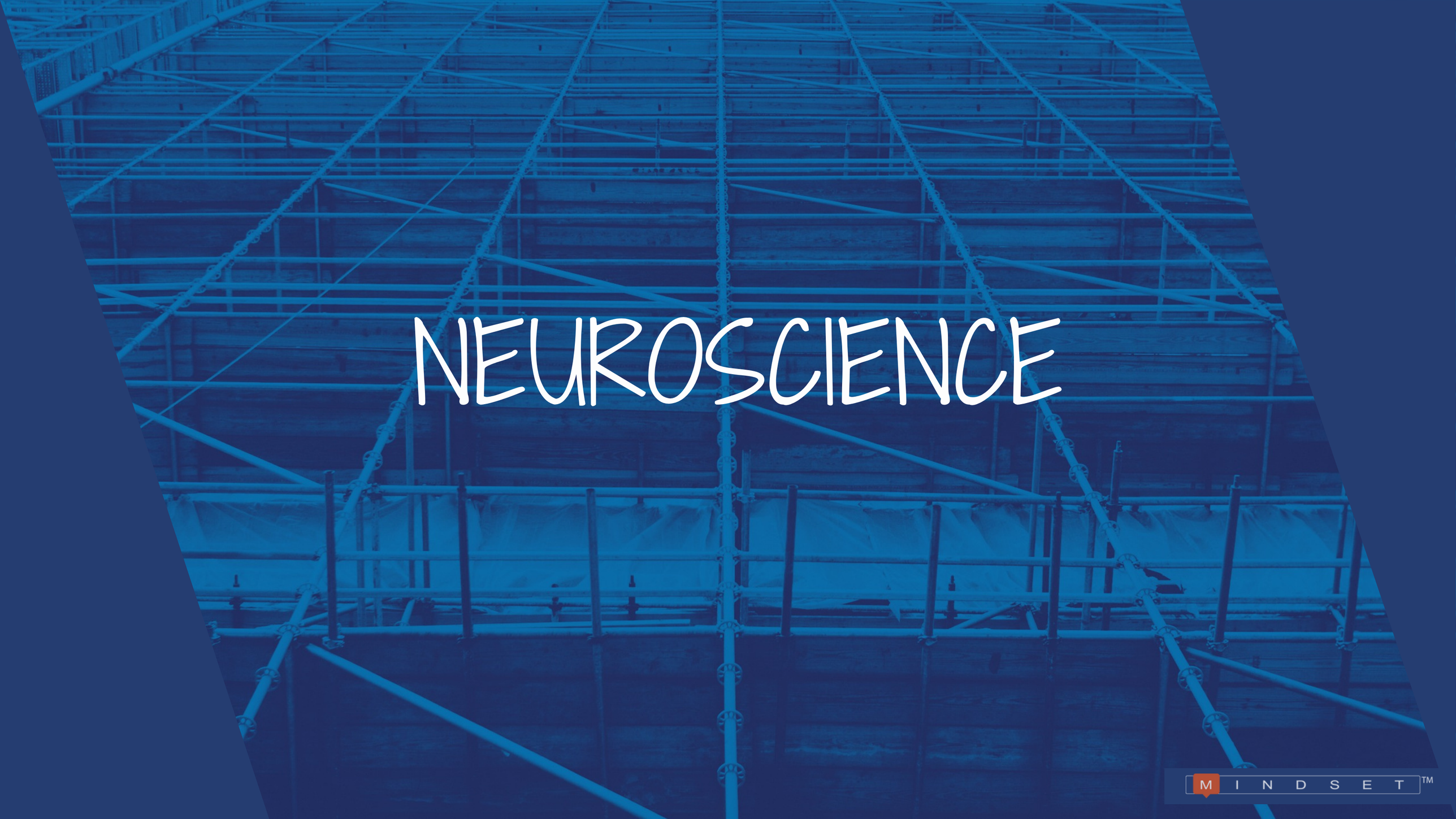
- Neuroimaging
  - CT and MRI
- Qualitative vs Quantitative Analyses

Diffusion Tensor Imaging

- Diffuse Axonal Injury
- Fractional Anisotropy

Brain Injury Evaluations

- Challenges with mTBI
- Imaging Correlations



Start with basics

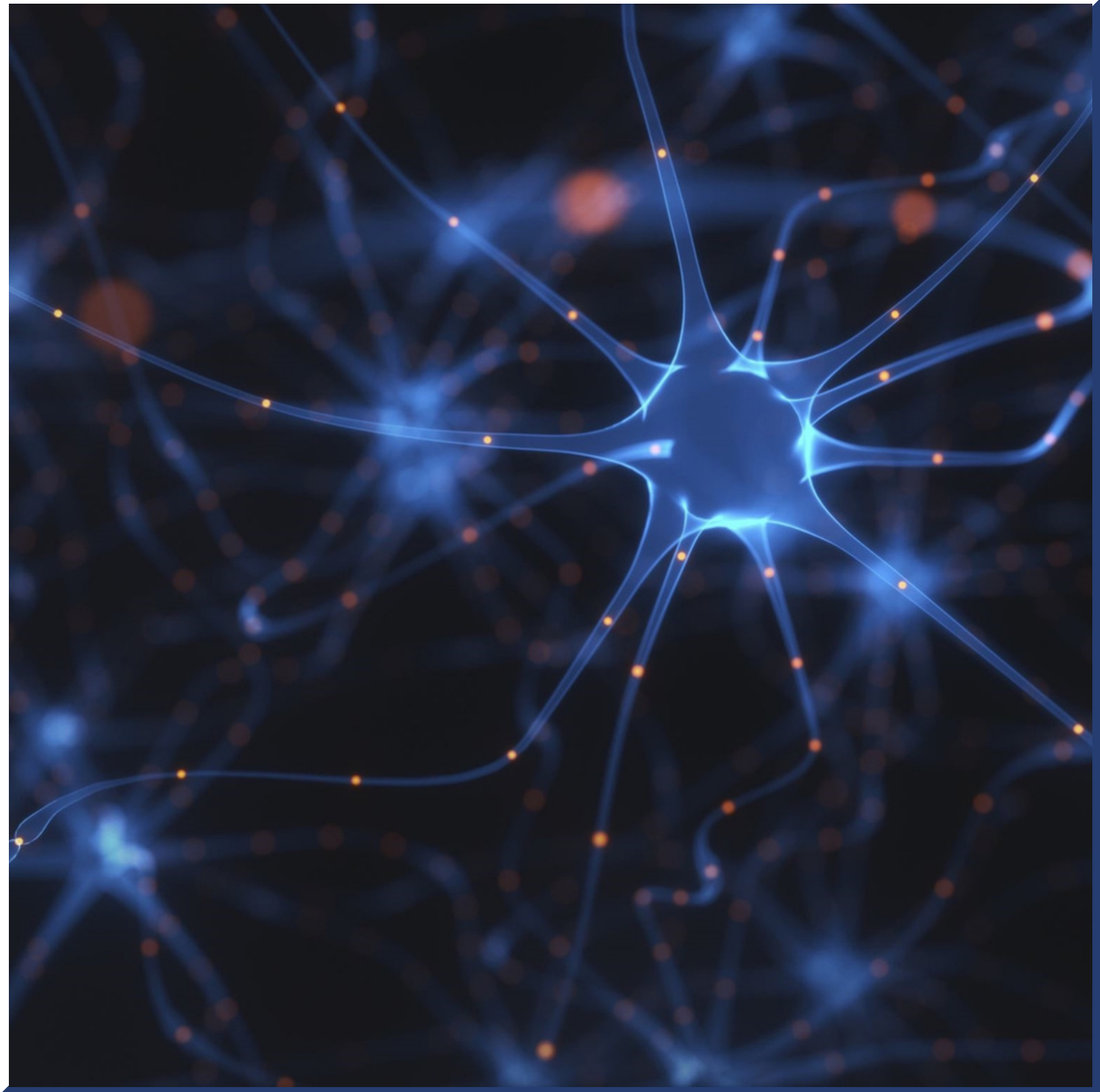
Definitions

Neuroscience

- any or all of the sciences that study the structure and function of the brain and nervous system.

Neuroimaging

- the process of producing images of the structure or activity of the brain or other part of the nervous system by techniques such as magnetic resonance imaging or computerized tomography.



Neuroimaging in Brain Injury

Computed Tomography (CT)

Preferred modality in the acute phase.

Why? Preferred over MRI because it is better for identifying fractures, vascular injury, CSF leaks, and doesn't require safety screening.

Magnetic Resonance Imaging (MRI)

Preferred modality in the subacute and chronic phase.

Why? Because of enhanced soft tissue contrast and higher sensitivity.

MRI data is not created equal

Traditional battery

~ 20-30 minutes data collection
Limited to standard sequences
Thicker slice
Lower resolution
Limited analysis options
Reviewed by radiologist or neuroradiologist

Advanced battery for hx of TBI

~ 60 minutes data collection
More sequences & sequences specific to trauma
Susceptibility Weighted Imaging (SWI)
Diffusion Tensor Imaging (DTI)
Thinner slice
Higher resolution
Allows for advanced analysis
Neuroradiologist with expertise in trauma

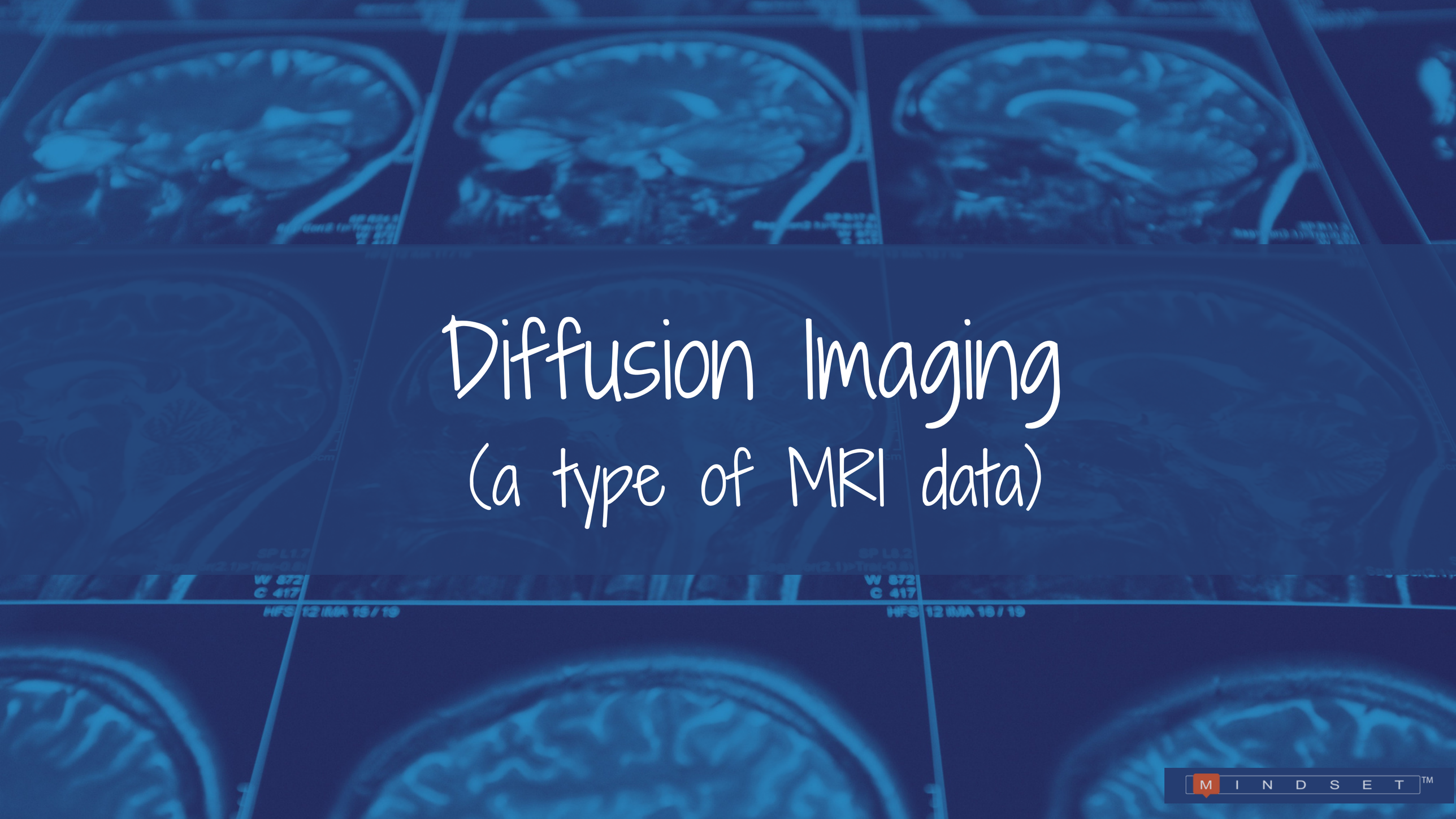
MRI review/analysis is not created equal

Qualitative

- Visual inspection by a human Radiologist vs Neuroradiologist
- Time and volume constraints
- Abnormality based on Neuroradiologist's experience

Quantitative

- Involves measurements
- Within-subject and between-subject
- Can involve normative data
- With enough normative data there can be statistically based conclusions of measurements being within or outside of normal limits



Diffusion Imaging
(a type of MRI data)

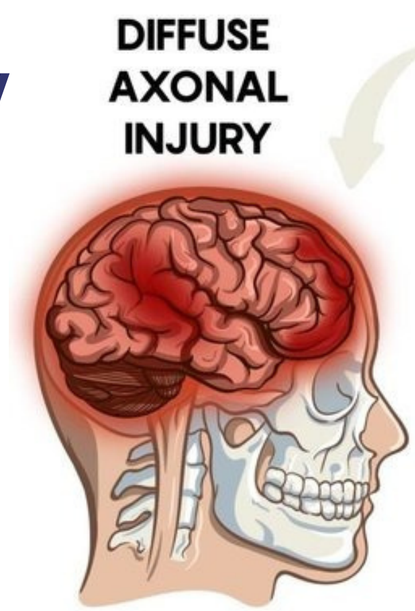
Diffusion Imaging

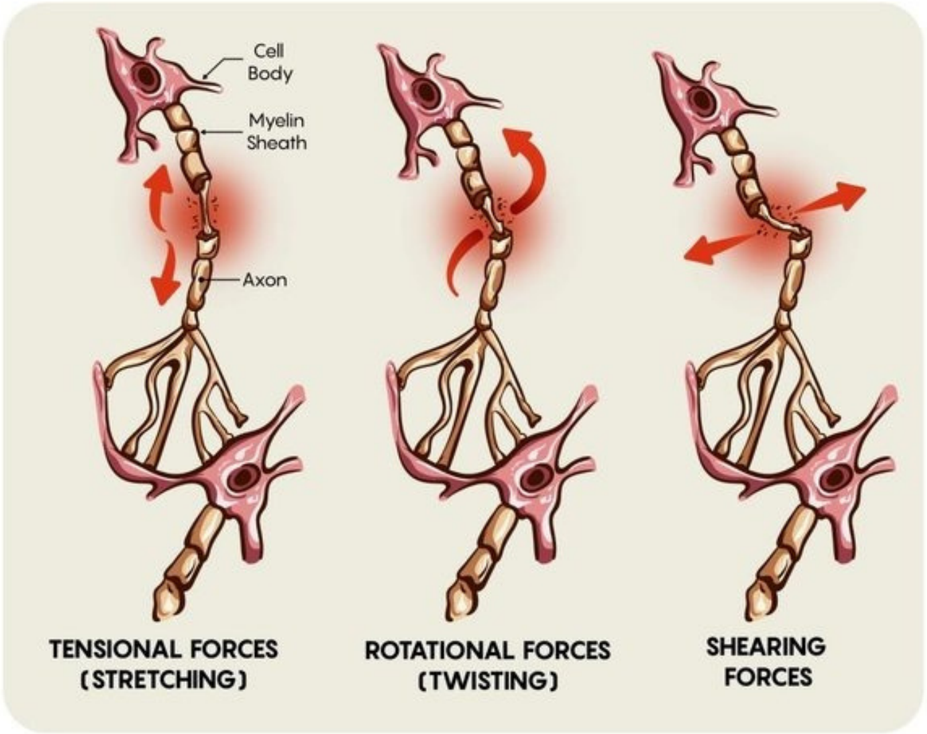
to evaluate white matter

- Diffusion Weighted Imaging (DWI)
- Diffusion Tensor Imaging (DTI)
- Fractional Ansiotropy (FA) values. Measure of white matter integrity.

Diffuse Axonal Injury

resulting from TBI





- Diffuse axonal injury (DAI) is a form of traumatic brain injury (TBI).

- The long connecting fibers in the brain – axons – can be **stretched, twisted, or sheared** as the brain rapidly accelerates and decelerates inside the skull.

Photo Credit Bray 2018 DOI: 10.13140/RG.2.2.35052.72327
https://www.researchgate.net/publication/340677811_Examining_Causes_and_Consequences_of_Mental_Health_Disorders_in_Chronic_Traumatic_Brain_Injury

Diffusion Imaging

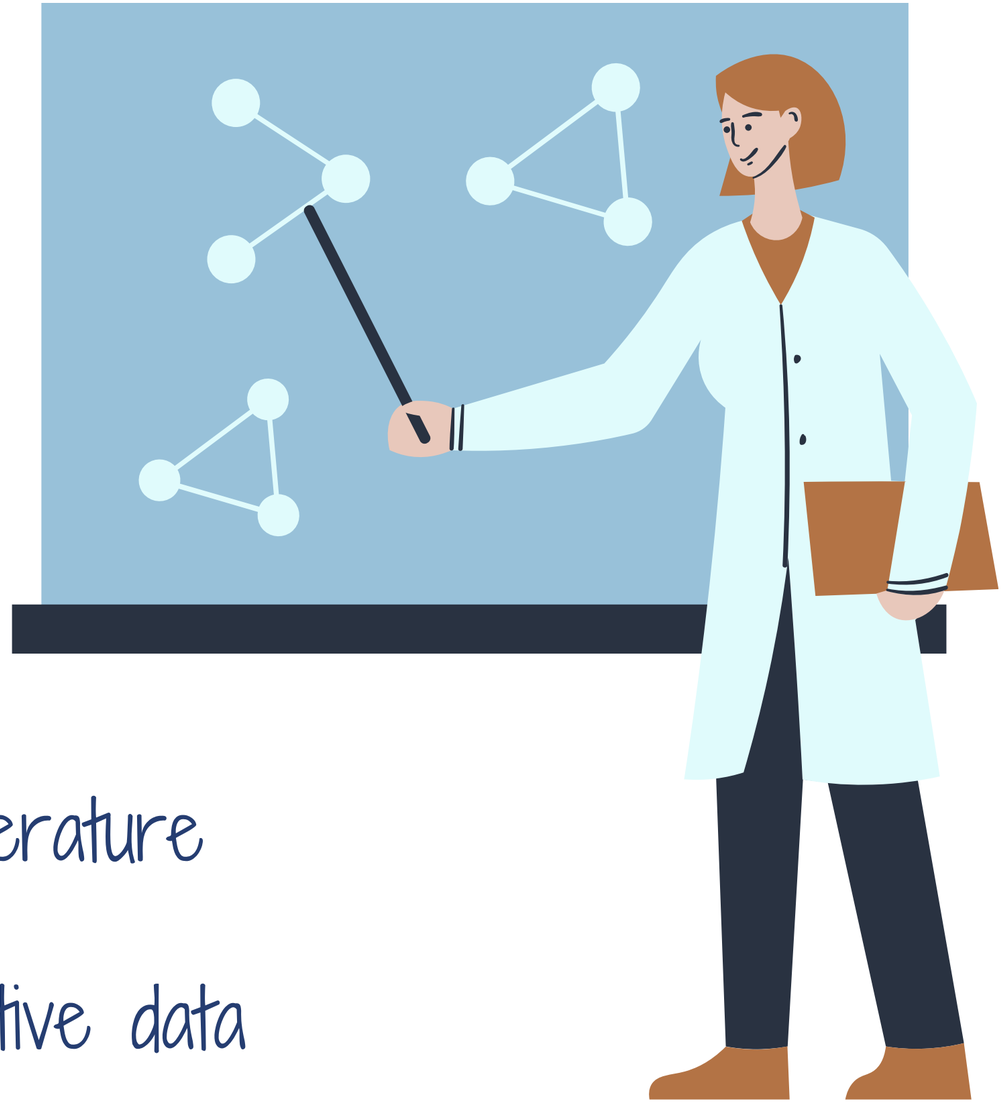
fractional anisotropy

- FA values range from 0 (isotropic movement of water molecules) to 1 (anisotropic movement of water molecules).

Diffusion Imaging

Types of DTI analyses to understand

- Visual review of DTI fiber tractography
- Asymmetry analysis of client FA values
- Comparison of client FA values to the literature
- Comparison of client FA values to normative data




If we really want to understand something, we should measure it.

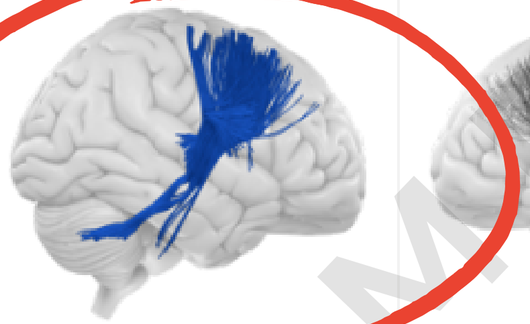
Quantitative Volumetric and Diffusion Tensor Imaging Analyses

Client Name:	Arroway, Eleanor
Date of Birth:	10/29/1988
Sex:	Female
Date of Data Collection:	07/14/2022
Date of Report:	07/18/2022

Summary

Volumetric analyses revealed 2 of the 107 evaluated brain regions to show abnormal volume on both isolated individual testing and following correction for multiple comparisons (0 low; 2 high). In addition, there were 5 regions (3 low; 2 high) that were atypical on isolated individual testing, but which did not survive correction for multiple comparisons.

DTI analyses revealed 3 of the 48 evaluated fiber tracts regions to show abnormal average FA on both isolated individual testing and following correction for multiple comparisons (3 low; 0 high). In addition, there were 4 regions (4 low, 0 high) that were atypical on isolated individual testing, but which did not survive correction for multiple comparisons.

Superior ngitudinal sciculus	R Superior Frontal-Occipital Fasciculus	L Superior Frontal-Occipital Fasciculus	R Uncinate Fasciculus
			

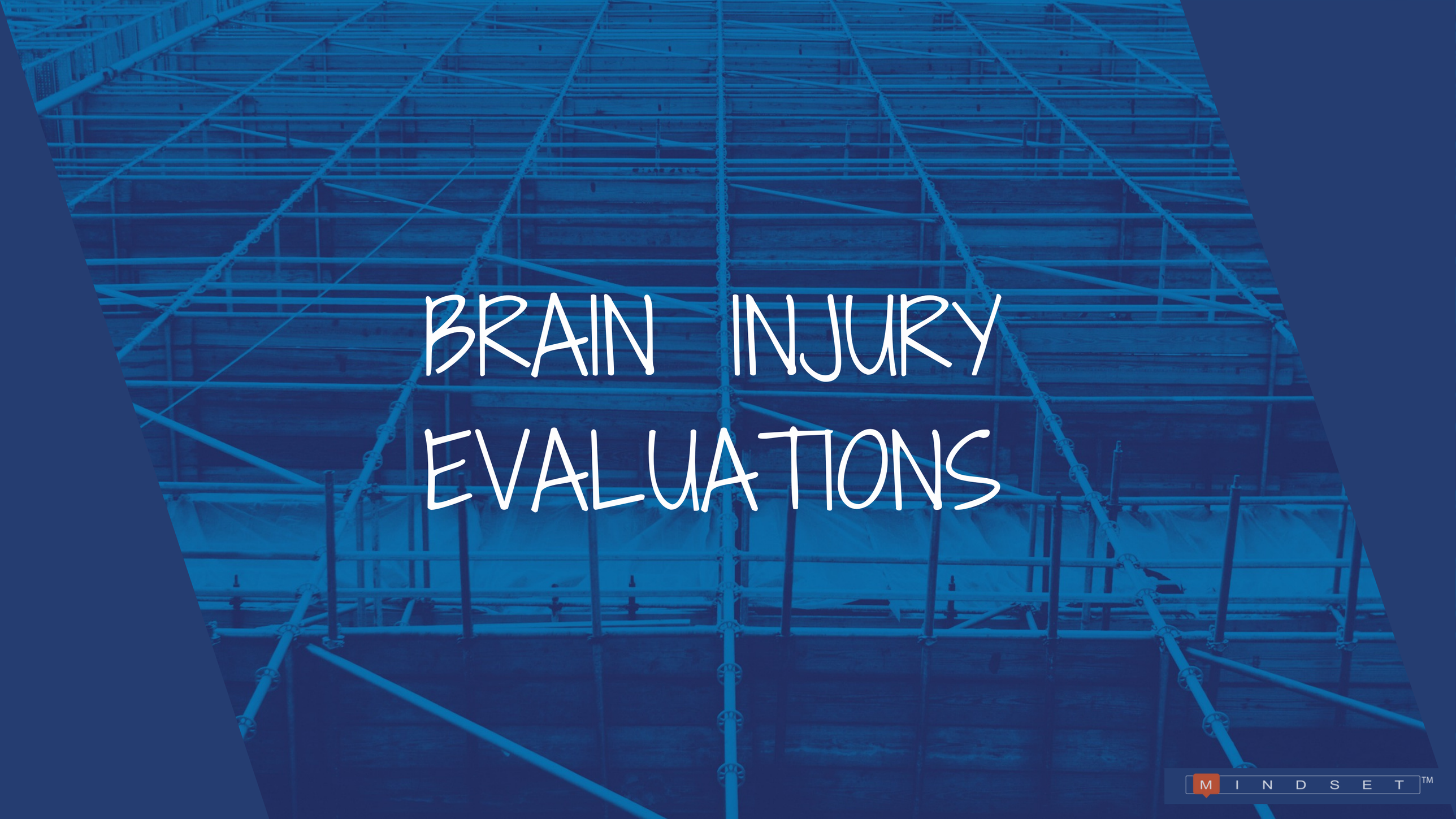
	|z| > 1.645, p<0.050	|z| > 1.960, p<0.025	|z| > 2.326, p<
Atypically Low			
Low, Survives BH Correction			
Atypically High			
High, Survives BH Correction			

Volumetric Analyses for Regions-of-Interest

Data are shown as Z-score deviates based on comparison of the client data with average data from the sex and age-range (+/-10 years) matched group of 274 control subjects.

Average FA Analyses for Fiber Tract Regions

Data are shown as Z-score deviates based on comparison of the client data with average data from the sex and age-range (+/-10 years) matched group of 271 control subjects.



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The impact is just the beginning

Primary mechanism of injury

+

Secondary neurobiological cascade

BRAIN INJURY EVALUATIONS NEED TO BE MULTIDISCIPLINARY

SOMATIC PSYCHIATRIC COGNITIVE

YOU NEED TO KNOW WHAT FUNCTIONAL IMPAIRMENTS YOU ARE LINKING IMAGING TO

TBI CHECK

Brings the standard of care for inpatient moderate/severe TBI screening, to the outpatient setting - a multidisciplinary assessment approach in one sitting.

WHO's it for? Every individual that may have suffered a TBI but has never been formally or fully assessed, or diagnosed, and would benefit from a **comprehensive symptom assessment.**

WHAT's in it? A series of tests (e.g. cognitive, balance, hearing etc.) that measure all of the areas of functioning known to be potentially impacted by a brain injury - in one appointment.

Location	Name (BA - Brodmann Area)	Left %	Right %	General Functions
Frontal	BA 04: Primary Motor Cortex	1	3	motor control
	BA 06: Pre/Supp Motor Cortex	<1	2	motor planning
	BA 08: Supp Motor, Eye Fields Cortex	4	5	eye movements
	BA 09: Dorsolateral Prefrontal Cortex	2	1	executive function, working memory
	BA 10: Anterior Prefrontal Cortex	<1	<1	executive function, planning
	BA 11: Orbital Frontal Cortex	1	<1	exec function, emotion, behavior
	BA 25: Subgenual, Ventromedial Prefrontal Cortex	26	18	exec function, decision making, emotion
	BA 44: Pars Opercularis (part of Broca's Area [L])	2	1	expressive language
	BA 45: Pars Triangularis (part of Broca's Area [L])	1	2	expressive language
	BA 46: Dorsolateral Prefrontal Cortex	5	<1	exec function, working memory
	BA 47: Pars Orbitalis	6	1	language, syntax
Parietal	BA 1: Primary Somatosensory Cortex	1	5	proprioception
	BA 2: Primary Somatosensory Cortex	<1	5	proprioception
	BA 3: Primary Somatosensory Cortex	<1	11	touch
	BA 05: Somatosensory Association Cortex	15	21	touch
	BA 07: Superior Parietal Lobule / Precuneus	<1	<1	visual spatial processing, attention
	BA 39: Inferior Parietal Lobule / Angular Gyrus	<1	<1	language, reading, attention, math
	BA 40: Inferior Parietal Lobule / Supramarginal Gyrus	<1	1	multimodal integration, attention, language
	BA 43: Primary Taste Cortex	14	6	taste
Occipital	BA 17: Primary Visual Cortex	<1	4	vision
	BA 18: Secondary Visual Cortex	<1	3	vision
	BA 19: Tertiary Visual Cortex	<1	<1	complex visual information processing,
	BA 37: Fusiform Cortex	25	18	word recognition [L]; face recognition [R]
Temporal	BA 20: Inferior Temporal Gyrus	41	19	visual recognition and memory
	BA 21: Middle Temporal Gyrus	7	1	complex auditory processing, language
	BA 22: Superior Temporal Region (including Wernicke's Area [L])	1	6	auditory processing, receptive language
	BA 38: Anterior Temporal Polar Region	4	<1	memory, language
	BA 41: Primary Auditory Cortex	11	29	auditory processing
	BA 42: Secondary Auditory Cortex	1	5	auditory processing
Limbic	BA 13: Insula	12	20	Sensory integration, emotional salience
	BA 23: Posterior Cingulate Cortex	2	17	emotion, memory, intrinsic control
	BA 24: Anterior Cingulate Cortex	31	4	exec function, decision making, inhibition
	BA 33: Anterior Cingulate Cortex	39	60	exec function, decision making, inhibition
	BA 29: Retrosplenial Cingulate Area	1	3	memory, motivation and emotion
	BA 30: Retrosplenial Cingulate Area	9	3	memory, motivation and emotion
	BA 27: Piriform Cortex	47	47	smell
	BA 28: Ventral Entorhinal Cortex	5	12	memory
	BA 31: Dorsal Posterior Cingulate Cortex	3	4	emotion, memory, intrinsic control
	BA 32 Dorsal Anterior Cingulate Cortex	20	14	exec function, decision making, emotion
	BA 34: Dorsal Entorhinal Cortex, Parahippocampal Gyrus	16	32	smell, memory

Why is it so complicated?

The brain that was injured +
The injury itself +
The environment after injury

"As a heterogeneous disorder, long-term outcome following TBI is dependent on the type and severity of the initial physical event (primary injury) compounded by multifaceted pathophysiological consequences (secondary injuries)."

Cullen et al. 2016 at 290 DOI 10.1007/978-1-4939-3816-2_17

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Summary

- Neuroscience has developed an extensive peer-reviewed published literature relating to understanding brain structural connectivity in health and disease.
- Neuroimaging that includes diffusion tensor imaging (DTI) data can provide evidence of brain compromise in individual patients that have suffered brain injury.
- Quantitative analyses that increase sensitivity of the neuroimaging data can be rigorous, reliable, and reproducible. All data should be interpreted in light of the patient's history and using the scientific method.
- When abnormal imaging findings in brain regions with functional correlates that match the symptoms a person is experience, there is strong convergent validity present.

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Questions? Feedback?

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Case Review | Case Consultation | Quantify | TBI CHEQ