Driving Safety in Patients with Generalized SWD but no Clinical Seizures: Evaluation with a Realistic Driving Simulator

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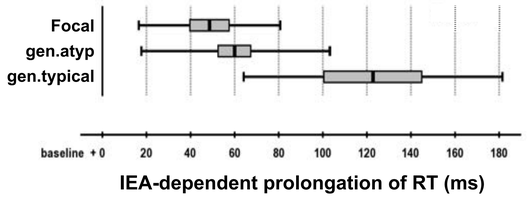
1. Introduction

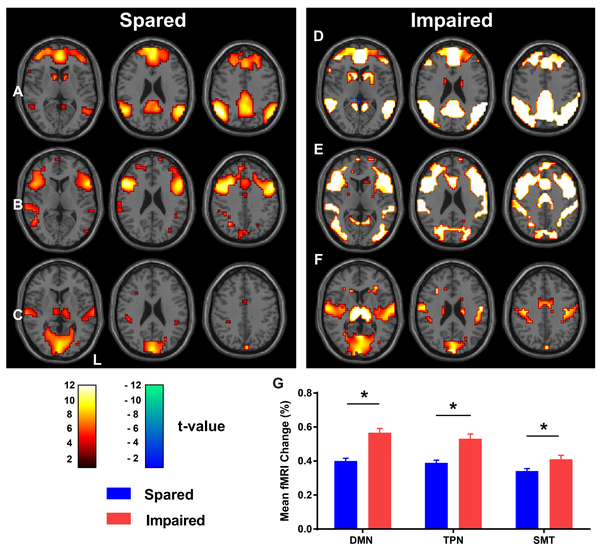
Generalized spike-wave discharges (SWD) are EEG hallmarks of generalized seizures and epilepsies. Our previous work shows that the amplitude and duration of SWDs on EEG are predictive of performance on the Repetitive Tapping Task (RTT) and the Continuous Performance Task (CPT) **[2]**. The effect of generalized SWDs on more complex behaviors like driving has been investigated in very limited studies with either small sample sizes or by using computerized driving games. Evidence from these studies suggests that generalized SWDs prolong reaction time and impair drivers' abilities to maintain car positions **[3, 4]**. At the same time, these generalized SWDs may persist as subclinical epileptiform discharges even in "seizure-free" patients who continue to drive, posing a significant challenge to driver licensing authorities, clinicians and patients. Although not clinically observed and not perceived by patients, these subclinical discharges can be accompanied by transient cognitive impairments **[5]**.

Primary Inquiry

To study the influence of generalized SWDs on driving behavior and safety in high fidelity simulated driving environments and to identify objective EEG features for predicting SWDs that impair driving ability.

2. Previous Findings





On Repetitive Tapping Task (RTT) and Continuous Performance Task (CPT), generalized SWD demonstrate more severe physiological response and fMRI changes during SWD which impair performance on the tests. (DMN = default mode network, TPN = task-positive network, SMT = sensorimotor-thalamic network)

Figures from Nirkko et al., Epilepsia 2016 (top) and Guo et al., Lancet Neurology 2016 bottom.

3. High Fidelity Simulated Driving Paradigm

Subject Recruitment

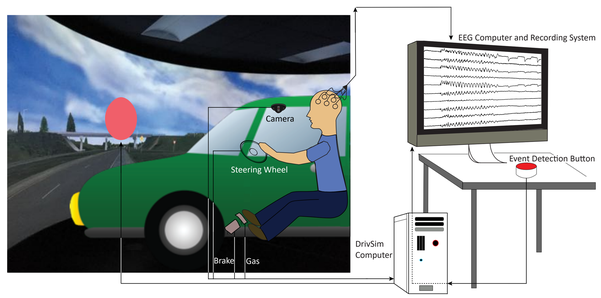
Subjects are recruited through epilepsy centers and neurologist offices in CT.

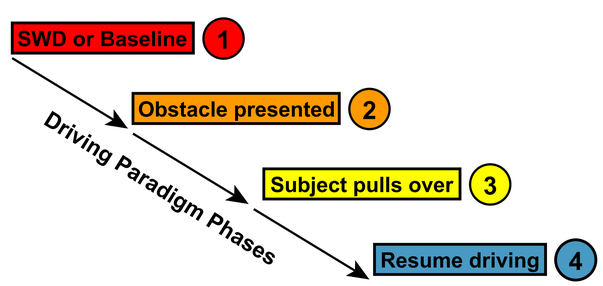
Inclusion and Exclusion Criteria

- 15+ years old
- At least 1SWD/hr on ambulatory EEG
- No clinical seizures in the last month
- No other neurologic disorder that impairs driving ability

Testing Paradigm

- > 5 minutes training session. *Task is to pull over when red oval appears.*
- 1 hour of testing with simultaneous video/EEG monitoring in the simulator

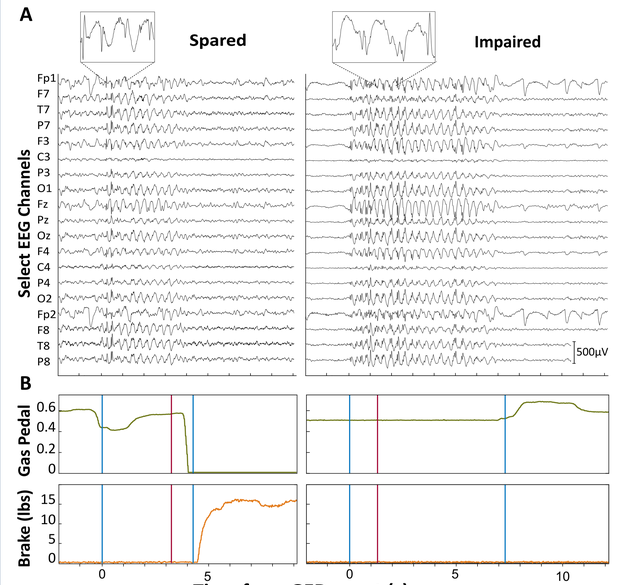




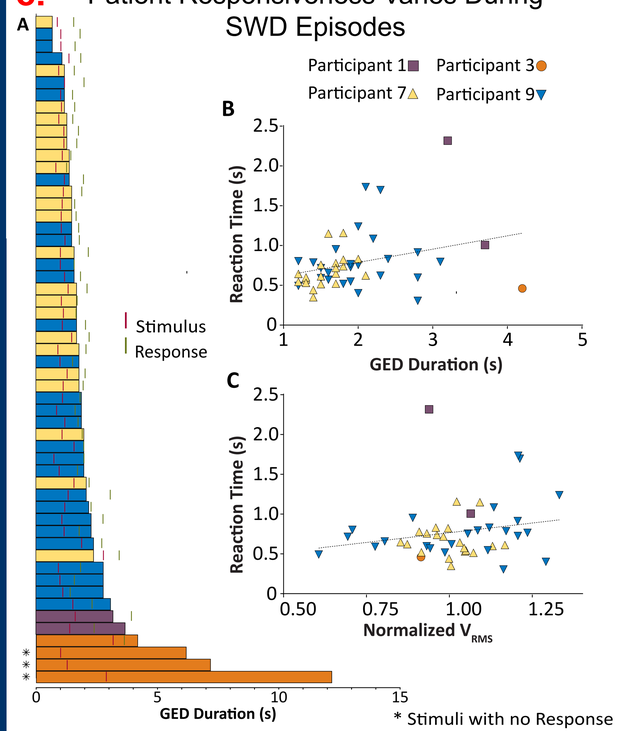
4. Subject Demographic & Clinical Information

Pt #	Sex	Age at drive (yrs)	Age epilepsy onset (yrs)	Treatment at time of study	Clinical seizure type	Driving experience?	EEG description	Total # of epileptiform discharges	# of discharges tested during drive
1	F	18	5	Lamotrigine, zonisamide	Absence	Yes	3.5-Hz generalized SWDs, often larger amplitude on left side	9	2
2	F	18	11	Lamotrigine, zonisamide	Absence, tonic-clonic, myoclonic	No	No epileptiform discharges	0	0
3	F	20	1	Levetiracetam	Absence, tonic-clonic, myoclonic	Yes	3-Hz generalized SWDs	7	4
4	M	33	10	Lamotrigine	Absence, tonic-clonic	Yes	14- to 18-Hz rhythmic generalized beta activity	14	0
5	F	43	10	Valproic acid	Absence, tonic-clonic	Yes	No discharges	0	0
6	M	18	13	Valproic acid	Absence	Yes	No discharges	0	0
7	F	76	74	Levetiracetam, lacosamide	Tonic-clonic	Yes	2- to 3-Hz generalized SWDs or polyspike and wave discharges	30	22
8	F	19	18	Lamotrigine, zonisamide	Absence, tonic-clonic	Yes	No discharges	0	0
9	F	20	11	Clobazam	Tonic-clonic	Yes	8- to 14-Hz generalized polyspikes evolving into 3- to 4-Hz generalized polyspike and wave discharges	28	27

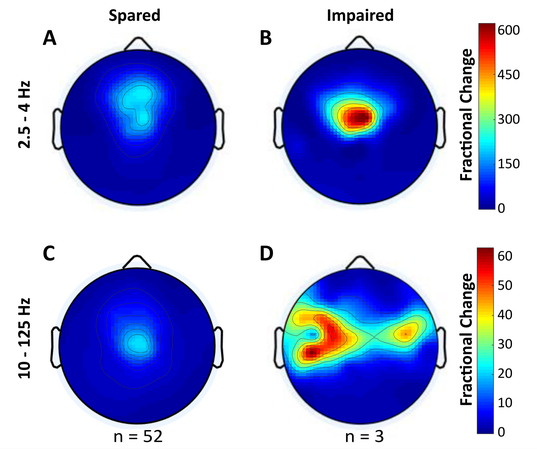
5. Behavioral Responses During SWD



6. Patient Responsiveness Varies During SWD Episodes



7. Fractional Power Change of SWD



8. Conclusions

- Generalized epileptiform discharges are not benign discharges and may confer varied impairments on cognition and behavior.

- Stationary, high-fidelity driving simulators instrumented for simultaneous EEG and video monitoring are feasible for studying driving behavior in patients with epilepsy.

- Similar to findings demonstrated in RTT and CPT, some generalized SWD spare behavior while others impair behavior, even in complex activities like driving.

- Subclinical generalized SWD that impair driving may have longer duration and greater spike and wave signal power on EEG.

9. Future Directions

- Future work should test larger cohort of subjects using the high fidelity simulated paradigm we have demonstrated.

- Modify paradigm to include automated, rather than manual, presentation of road obstacles.

- Machine learning with larger datasets to develop algorithms for distinguishing between "safe" vs "unsafe" SWD based on EEG features.

10. References

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