Evaluation of the SleepScore Labs Sonar and Radiofrequency Sleep Sensor Technologies by ResMed™

At SleepScore Labs we understand access to accurate, validated sleep measurement in the consumer space fosters sleep awareness and motivates improved sleep behavior. Although consumer sleep technology validation data is often lacking, its importance is highlighted by the recent American Academy of Sleep Medicine's Position Statement stressing the necessity of validation of these new sleep measurement tools (Khosla et at, 2018). We support this point of view. The performance results of the ResMed Sensor Technologies used by SleepScore Labs have been published in peer-reviewed journals and abstracts over the years. A full list of the published studies is found at https://www.sleepscore.com/the-science-2

In this brief info-sheet, we show initial validation results against polysomnography (PSG) of the new Sonar signal-based sleep annotation and our current radiofrequency (RF) signal-based sleep annotation (as implemented in SleepScore Max). Both RF and Sonar are non-contact measurement methods and have the advantage over both wearables and in-bed sensors by not impacting user comfort. Both sensors detect motion, and hence can detect gross motion, micromotion and the full respiratory signal during sleep. The research was conducted by an independent sleep laboratory in 38 healthy individuals. Samsung S7 smartphones were used as hardware for the Sonar measurements, whereas S+ SleepSensor by ResMed was used for the RF measurements. Both Sonar and RF signal-based annotations were compared against PSG sleep annotations on an epoch by epoch (or period) basis. PSG sleep stages N1 and N2 were combined into Light sleep to map the output of the Sonar and RF sleep annotation. Please note this info-sheet is preliminary and the full set of results will be published in a peer-reviewed academic journal later this year.

Annotation performance of both the Sonar and RF sensor technologies are shown in Table 1 and Figure 1 & 2 below. *Sensitivity* reflects the ability to annotate a specific sleep stage epoch correctly compared to PSG (e.g. all correctly annotated Wake epochs / All PSG Wake epochs). *Accuracy* represents the correct annotation of both the occurrence and non-occurrence of a certain sleep stage epoch compared to PSG (e.g., all correctly annotated Wake epochs and correctly annotated non-Wake epochs / All PSG epochs). *Specificity* reflects the ability to annotate the non-occurrence of a specific sleep stage epoch correctly compared to PSG (e.g., all correctly annotated non-Wake epochs / All PSG non-Wake epochs).

Table 1: Sleep Staging Performance

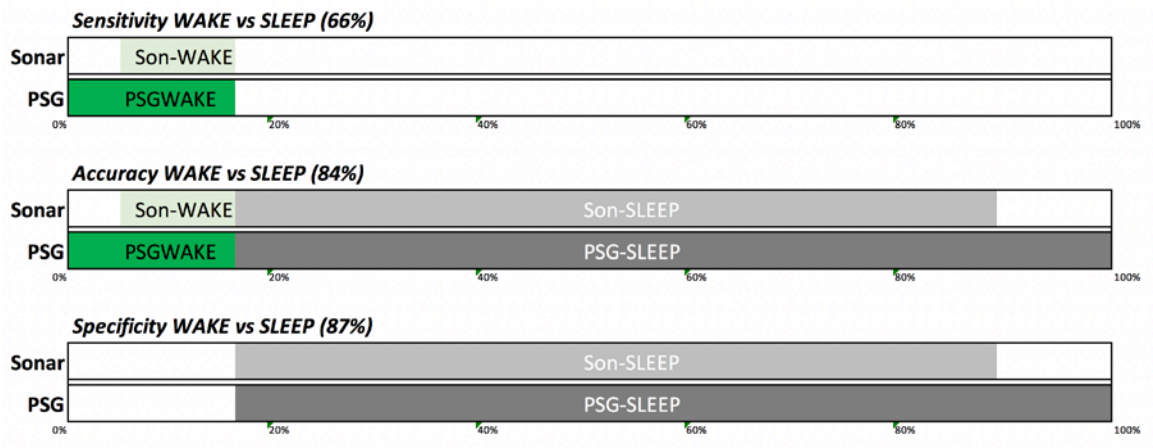
		Sensitivity	Accuracy	Specificity
WAKE				
	Sonar	66%	84%	87%
	RF	57%	87%	93%
LIGHT				
	Sonar	58%	64%	70%
	RF	66%	65%	64%
DEEP				
	Sonar	60%	83%	89%
	RF	55%	84%	91%
REM				
	Sonar	59%	89%	93%
	RF	65%	89%	92%

The performance of the RF and the Sonar measurements are highly comparable. For Wake, Deep and REM sleep annotation, the performance on accuracy and specificity are high (all >83%). The sensitivity results compare favorably with top range multi-sensor full contact wrist worn sleep trackers (de Zambotti et al., 2017). For comparison, human PSG interscorer agreement is 73% (Norman et al., 2000).

These results show that non-contact Sonar technology on a smartphone and RF technology within a bedside device can accurately determine sleep stages in normal healthy adults. The results compare favorably to those reported by other consumer sleep technologies.

Figure 1: Sleep Staging Performance

Figure 2: Reading guidance Sleep Staging Performance Graphs
Using Sonar Wake epoch performance as an example



Sensitivity: All correctly annotated Wake epochs / All PSG Wake epochs; (Son-WAKE /PSGWAKE).

Accuracy: All correctly annotated Wake epochs and correctly annotated non-Wake epochs / All PSG epochs; (Son-Wake + Son-SLEEP) / (PSGWAKE + PSG-SLEEP)

Specificity: All correctly annotated non-Wake epochs / All PSG non-Wake epochs; (Son-SLEEP /PSG-SLEEP).

References:

Khosla S, et al. Consumer sleep technology; an American Academy of Sleep Medicine position statement. *J Clin Sleep Med*. 2018;14(5):877-880

de Zambotti M. et al. A validation study of Fitbit Charge 2™ compared with polysomnography in adults. *Chronobiol Int*. 2017;35(4): 465-476

Norman R. et al. Inter-observer agreement among sleep scorers from different centers in a large dataset. *Sleep*. 2000; 23(7):901-8.

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