The timing precision of iOS and Android apps

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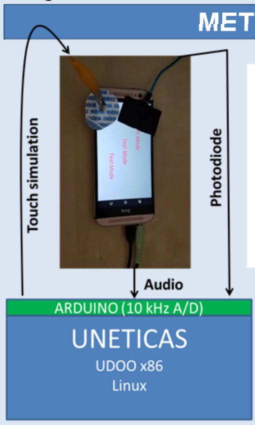
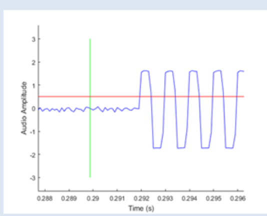
SUMMARY

Is the timing precision of mobile apps sufficient for cognitive neuroscience research? METHODS: We used UNETICAS, the Universal Networked Event-Timing Calibrator and Scope, to calibrate mobile app timing precision by synchronizing devices over a wireless network with the Lab Streaming Layer protocol. Calibration tests were programmed with Presentation® on a Windows PC. The same code was used in Presentation® Mobile apps for iOS and Android devices. RESULTS: Mobile apps showed reliable, device-specific latencies of stimulus delivery (range 1.3 to 23 ms, standard deviations < 1.0 ms). The time needed to detect touch responses ranged from 7 to 32 ms (standard deviations < 9.0 ms). CONCLUSION: When corrected for device-specific latencies, Presentation® Mobile app timing was nearly as precise as that of Windows Desktop computers and is sufficient for the reliable and precise behavioral and/or electrophysiological testing of sensory and cognitive function.

METHODS





Display screen showing an auditory trial. Green line: Presentation® Mobile time. Red line: threshold. Sound: 1 kHz tone.

Figure 1. UNETICAS. Timing delays were measured with the Universal Networked Event Timing Calibrator and Scope (UNETICAS). Latencies were measured by taking the difference in the event times (sound, image, touch) reported by Presentation® Mobile with the corresponding times of physical occurrence as measured by UNETICAS. Each test included a minimum of 8,000 events.

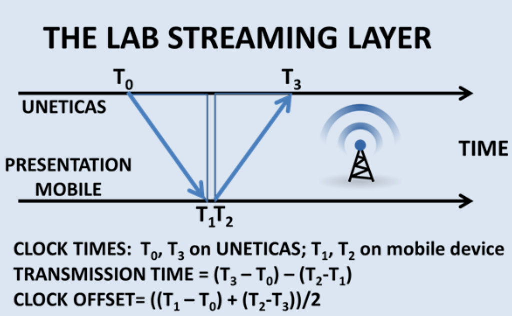


Figure 2. The Lab Streaming Layer. Mobile timing synchronization was performed with the Lab Streaming Layer (LSL) over a 5 GHz wireless network. The time of the high-precision clock on the mobile device was corrected for clock offset to conform to the UNETICAS time base. This enabled the event times reported by Presentation® Mobile to be compared to their actual time of occurrence as recorded by UNETICAS, The influence of LSL transmission variability on event latencies was less than 0.02 ms on all devices.

RESULTS

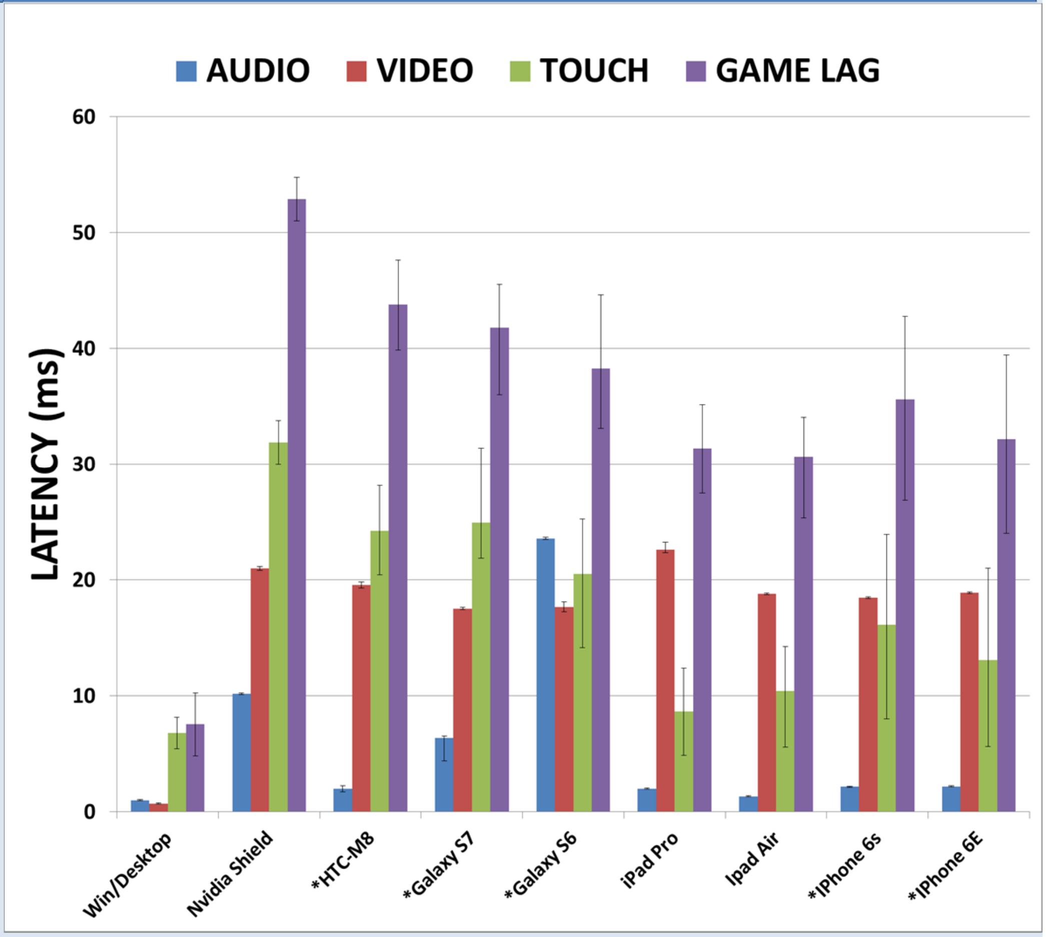


Figure 3. Median latencies of different mobile devices. Error bars show 90% confidence intervals for individual trials. Data from a Windows desktop computer with a CRT monitor were gathered previously and are included for comparison**.** Game lag = touch latency + visual stimulus latency. * = Mobile phone.

DISCUSSION

Presentation® Mobile apps showed the high-precision timing required by research studies in cognitive neuroscience (Figure 4), regardless of the mobile device tested. Following device-specific latency corrections, latency standard deviations (SDs) for auditory and visual stimuli were less than 1 ms. This level of precision makes it possible to record electrophysiological responses with minimal distortion (Figure 4) by interfacing Presentation® Mobile through the Lab Streaming Layer. We found that different latency corrections were required to compare behavioral performance across devices. For example, touch processing was delayed relative to audio stimulus delivery on the Nvidia shield, increasing auditory reaction times (RTs) by 23 ms, while auditory stimuli were delayed relative to touch on the Galaxy 6S, reducing RTs by 3 ms. Different adjustments would also be required to deliver simultaneous auditory and visual stimuli on different devices; e.g., sounds need to be advanced by 3 ms on the HTC-M8 and delayed by 21 ms on the iPad Pro. Game lag measures were shorter for the desktop PC than for the mobile devices. However, mobile-device game lags were similar to those previously reported for desktop computers [1], again demonstrating the rapid responsivity of Presentation® Mobile apps.

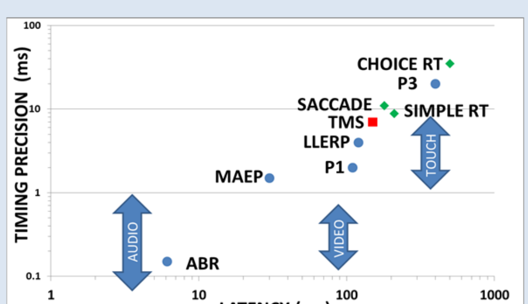


Figure 4. Timing precision required for different research techniques. Arrows show the range of mobile timing precision for audio, visual, and touch events across devices. Data points show the precision needed for different techniques, including ERPs (blue circles): ABR = auditory brainstem response, MAEP = middle latency auditory evoked potentials, P1 = P100 of pattern reversal visual evoked potential, LLERP = long-latency ERPs, P3 = P300. TMS (red square) = transcranial magnetic stimulation, as we;; as saccadic eye movements, and RT = reaction times (green diamonds).

1.Raaen K, Petlund A, editors. How much delay is there really in current games? Proceedings of the 6th ACM Multimedia Systems Conference; 2015: ACM.