

The Effects of Adaptive Synchronization on Performance and Experience in Gameplay

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Abstract

As graphics (GPU) hardware has improved, fixed refresh rate displays became a significant throttle on graphics performance. GPU and display manufacturers therefore introduced adaptive synchronization (Async), which allows displays to adaptively synchronize to GPUs, avoiding rendering stalls and improving frame rate mean and variation. This research is a first experimental examination of the effects of Async on the experience of dedicated (but not professional) gamers. Participants played a first-person shooter (FPS) game, both with Async on and with Async off. After each game session, we assessed participant emotional state and gaming performance. We learned that at least for this popular FPS, Async can improve gaming performance, and may also benefit experience. We also found that Async has intriguing relationships to game familiarity and years of gameplay that merit additional investigation. Further research should examine these relationships, as well as Async's effects in systems with higher frame rates.

CCS Concepts

• **Human-centered computing** → *Displays and imagers; Empirical studies in HCI*; • **Applied computing** → *Computer games*;

1. Introduction

For decades, computer displays with fixed refresh rates have set the pace of real-time graphic display. And for decades, this made good sense, with frame generation happening more slowly than display refresh. However as graphics hardware (GPUs) improved, displays became a significant throttle on graphics performance. GPU and collaborating display manufacturers therefore introduced adaptive synchronization (Async), a technology that allows GPUs to adaptively synchronize display rates to frame rates, thus lowering frame time mean and variation. NVIDIA's proprietary implementation is called G-SYNC, while FreeSync is AMD's competing and open standard.

Async promises improved gaming experience for the broader gaming market. NVIDIA claims that G-SYNC display systems are "go-to equipment for enthusiast gamers," giving them "more of what [they] want in a gaming experience." AMD similarly urges gamers to "maximize [their] gaming experience" with FreeSync.

This research is a first experimental examination of the effects of Async on the experience of dedicated (but not professional) gamers. In this study, both very and moderately experienced gamers played a first-person shooter (FPS), with Async on and with Async off. As they played, we recorded Async's effects on their gaming performance and experience.

2. Experiment

Async improves temporal sampling and reduces delay. Previous research shows enhancements like these boost human performance, and may also result in better experience [CT07] We anticipated that Async would have similar effects, and tested that expectation in an experiment. In the process, we also hoped to learn something about how such improvements interact with learning and expertise, which prior work does not significantly address.

We experimented with an FPS game (Battlefield 4) because prior research showed that frame rate changes affect FPS performance [LC15], and because FPS frame rates do vary considerably over time, which should make Async particularly valuable. We had 27 participants in our experiment. All were students from undergraduate or graduate Computer Science courses with a prior experience with FPS games. To introduce Async, we used NVIDIA's G-SYNC. We used a 144Hz G-SYNC monitor, and an NVIDIA GTX 750 GPU on a Windows 8 PC with mouse and keyboard. With this system, frame rates varied around a mean slightly above 30Hz.

Our experiment had three independent variables: G-SYNC on/off (GS), G-SYNC first/second (GS1), and the participant's years of gaming (YG) experience. Figure 1 sketches our procedure. When participants arrived, we randomly assigned them to either the GS1 true or the GS1 false group. They then moved through several experimental stages, organized around two recorded gameplay sessions. During our experiment, we asked participants to

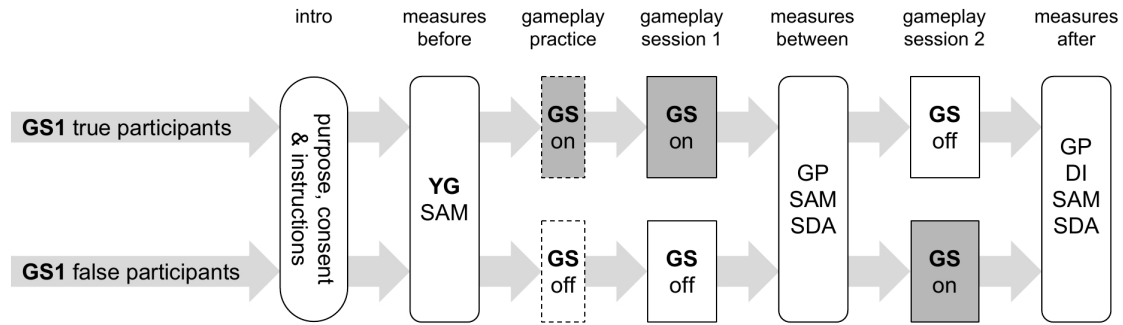


Figure 1: Our experimental procedure, and how it relates to independent variables and dependent measures.

indicate their emotional state using the self-assessment manikin (SAM) [BL94], which employs pictorial stimuli to aid description of emotion in a three-dimensional model [MR74]. We also recorded participants' Battlefield 4 score for our *gaming performance* (GP) measure. At the end of the experiment, asked participants to identify the gameplay session that was equipped with G-SYNC, which created our *display identification* (DI) measure.

3. Results and Discussion

Figure 2 shows our primary results. *Async* improved gaming performance significantly. Moreover, an interaction showed that this effect was lasting, even when participants continued playing without *Async*. It may be that *Async* aids in learning and speeds adaptation to new gaming environments. Effects on gaming experience were more complex. First, we note that participants could not identify the gaming session with *Async* at above chance levels, so experiential results did not suffer from conscious bias. Despite this, an interaction showed that when participants moved from gameplay without *Async* to gameplay with it, they experienced an increase in pleasure. Those who played first with then without experienced a moderate drop in pleasure. We speculate that learning to deal with new gaming challenges reduced *Async*'s effect on pleasure in the first gaming session, but not in the second. Finally, an interaction showed that for all but the most experience gamers, *Async* increased dominance. The most experienced gamers in fact experienced reduced dominance with *Async*. We believe that only the most experienced gamers were able to use *Async*'s improvements to better assess their own gaming performance.

This work should not be over-generalized. In particular, while the 30Hz frame rates in our setup are still very meaningful in the console market and for less avid PC gamers, we should examine *Async* effects at higher frame rates. We also studied those effects with only one game genre, using participants somewhat uniform in age and gaming familiarity. Nevertheless, gamers will be glad to have evidence that *Async* can improve gaming performance, and have beneficial impacts on gaming experience.

4. Conclusion and Future Work

This preliminary report explored the benefits to gaming performance and experience realized by adaptive synchronization technologies such as G-SYNC. We learned that in at least one popular

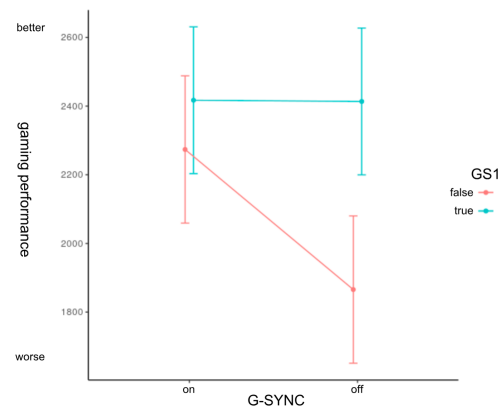


Figure 2: $G\text{-SYNC} \times G\text{-SYNC}$ first effects on gaming performance, with 95% confidence intervals.

FPS, *Async* can improve gaming performance, and may also benefit experience. But this research merits extensive follow-up, examining not only systems with higher frame rates, the broader milieu of gaming platforms and types, and more diverse or perhaps more experienced gamers; but also the complexity of our experimental results and other emerging measures of experience, including biophysical measures and the implicit association test. It may in fact prove that G-SYNC benefits other applications than gaming, and should be more widely adopted in the computing world.

References

- [BL94] BRADLEY M. M., LANG P. J.: Measuring emotion: the self-assessment manikin and the semantic differential. *Journal of behavior therapy and experimental psychiatry* 25, 1 (1994), 49–59. 2
- [CT07] CHEN J. Y., THROPP J. E.: Review of low frame rate effects on human performance. *IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans* 37, 6 (2007), 1063–1076. 1
- [LC15] LEE W.-K., CHANG R. K.: Evaluation of lag-related configurations in first-person shooter games. In *Proceedings of the 2015 International Workshop on Network and Systems Support for Games* (2015), IEEE Press, p. 11. 1
- [MR74] MEHRABIAN A., RUSSELL J. A.: *An approach to environmental psychology*. the MIT Press, 1974. 2