References

Actis Grosso, R., & Stucchi, N. (2003). Shifting the start: Backward mislocation of the initial position of a motion. *Journal of Experimental Psychology: Human Perception and Performance, 29,* 675-691.

Actis Grosso, R., Stucchi, N., & Vicario, G. B. (1996). On the length of trajectories for moving dots. In: Masin, S. C. (ed). *Fechner Day 1996. Proceedings of the Twelfth Annual Meeting of the International Society for Psychophysics*. The International Society for Psychophysics, Padua, 185-190.

Baldo, M. V. C. & Klein, S. A. (1995). Extrapolation or attention shift? *Nature, 378*, 565- 566

Bates, D. (2007). lme4: Fit linear and generalized linear mixed-effects models. *R package version version 14* October 2007.

Bastianelli, A., Actis-Grosso, R., Stucchi, N. (2004). Onset and offset localization: the effect of velocity modulation. In A. M. Oliveira, M. Teixera, G. F. Borges, M. J. Ferro (Eds), *Fechner Day 2004: Proceedings of the 20th Annual Meeting of International Society for Psychophysics* (pp. 298-303). Coimbra, Portugal: International Society for Psychophysics.

Bastianelli, A., Actis Grosso, R., Stucchi, N. (2005). Motion acceleration effects the localization of the vanishing (but not of the starting) point: in Monahan, J., S., Sheffert, S., M., Townsend, J., T. (ed). *Fechner Day 2005. Proceedings of the 21th Annual Meeting of the International Society for Psychophysics.* The International Society for Psychophysics, Traverse City, Michigan 29-34.

R Development Core Team (2007). *R: A language and environment for statistical computing.* R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org

Freyd, J. J. & Finke, R. A. (1984). Representational momentum. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10,* 126–132.

Fröhlich, F. W. (1923). Über die Messung der Empfindungszeit [On measuring sensation time]. *Zeitschrift für Sinnesphysiologie, 54,* 58–78.

Hubbard, T. L., & Bharucha, J. J. (1988). Judged displacement in apparent vertical and horizontal motion. *Perception and Psychophysics, 44* , 211-221

Kreegipuu, K., & Allik, J. (2003). Perceived onset time and position of a moving stimulus. *Vision Research, 43,* 1625-1635.

Krekelberg, B., & Lappe, M. (1999). Temporal recruitment along the trajectory of moving objects and the perception of position. *Vision Research, 39,* 2669–2679.

MacKay, D. M. (1958). Perceptual stability of a stroboscopically lit visual field containing sulfluminous object. *Nature, 181,* 507-508.

Nijhawan, R. (1994). Motion extrapolation in catching. *Nature, 370*, 256–257.

Müsseler, J., & Aschersleben, G. (1998). Localizing the first position of a moving stimulus: The Fröhlich effect and an attention-shifting explanation. *Perception & Psychophysics, 60,* 683-695.

Patel, S. S., Ogmen, H., Bedell, E., & Sampath, V. (2000). Flash-lag effect: differential latency, not postdiction [Technical Comment]. *Science, 290*, 1050–1051a.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods (2nd ed.).* Thousand Oaks, CA: Sage.

Scocchia L, Grosso R A, Baud-Bovy G, Stucchi N, 2006, "The specificity of motor control in perceiving the flash-lag effect" Perception 35 ECVP Abstract Supplement

Thornton, I. M. (2002). The onset repulsion effect. *Spatial Vision, 15*, 219–243.

PRACTICE MODULATES THE EFFECT OF EXPECTING A GAP IN TIMING

Paule Ellefsen-Gauthier, Claudette Fortin and Yves Lacouture
École de psychologie, Université Laval, Québec, QC, Canada
paule.ellefsen-gauthier.1@ulaval.ca,
claudette.fortin@psy.ulaval.ca, yves.lacouture@psy.ulaval.ca

Abstract

In previous studies on time production with gaps, participants were asked to interrupt and then to resume timing during a time interval production. Produced intervals consistently lengthened as the gap occurred later, revealing temporal underestimation related to pregap duration. This effect was explained by referring to two main mechanisms: 1) attention sharing between timing and monitoring for the gap signal, and 2) preparation to interrupt timing while the gap is expected. In the present study, two participants were tested in a 2.5-s time production task with gaps in 20 experimental sessions. Produced intervals lengthened with increasing value of gap location as in previous studies, but this effect was clearly modulated by practice: the slopes of functions relating produced intervals to gap location generally increased during the first 10 experimental sessions, and then stabilized. In contrast, the intercepts of these functions were unaffected by practice. These results suggest that practice specifically influences processes related to gap expectancy, namely, attention sharing and/or preparation to interrupt timing.

When timing has to be interrupted and then resumed during a gap in time interval production, an effect of varying gap location is consistently found: produced intervals are longer when the gap occurs later during the interval (Fortin & Massé, 2000; Fortin, Bédard & Champagne, 2005). This effect is explained by attentional time-sharing between timing and monitoring for the gap signal when a gap is expected, which shortens perceived time and thus delays the reach of the target interval. This interpretation is supported by results showing that a) in trials where a gap is expected but does not occur, produced intervals are even longer and b) when participants are forewarned of the gap absence, the effect is almost abolished. Another factor contributing to the effect is that when the gap occurs later, participants are better prepared to interrupt timing as soon as the gap signal is presented, which also results in relatively shorter perceived durations, hence longer productions (Bherer, Desjardins & Fortin, 2007). The present experiment tested whether the effect of varying gap location would be influenced by extensive practice of time production with gaps. Although attentional time-sharing failed to reduce interference under dual-task conditions when one of the two tasks was a timing task (Brown, 1998), practice usually improves performance in time-sharing situations (T. L. Brown & Carr, 1989). Besides, if temporal uncertainty concerning the possible values of gap location is reduced through practice, better preparation to interrupt timing when the gap signal occurs might amplify the gap location effect.

Method

Two participants (2 women, 20 and 23 years old) first practiced producing a 2.5-s interval, which was the target interval that had to be produced throughout the experiment, in practice sessions. They were then tested in 20 experimental sessions, in which they produced the same time interval in each trial, but with an interruption in timing (corresponding to the gap) during the interval production.

A PC-compatible computer running MEL-2 program controlled stimulus presentation and data recording. Each subject was tested individually in a quiet test room. At the beginning of each of the two practice sessions, the target interval was presented five times to the participants in the form of a 2.5-s tone. In the following trials, participants practiced producing the 2.5-s time interval with and without feedback on time production accuracy. In each practice trial, the participant pressed a key to begin the time interval production; this keypress triggered the beginning of a tone presentation. When it was judged that the tone had reached the previously presented target duration, the participant pressed the same key anew to end the interval production. The two time production practice sessions included five 48-trial blocks. In the first four blocks, a feedback informed the participant on time production accuracy: a message on the screen indicated whether the interval produced by the participant was too short, too long, or correct within a 10% temporal window centered on the target interval. There was no feedback in the last block of the practice sessions.

The 20 following experimental sessions were generally completed at a rate of one session per day, although two sessions could be completed in the same day with a minimum delay of one hour between sessions. Each session included one 48-trial block and four 36-trial blocks. The first block was a block of practice of time interval production with feedback and was identical to the first four blocks of the practice session. The objective of this block was to reset the representation of the target duration at the beginning of each experimental session. The four following blocks were constituted of 36 experimental trials. In these trials, there was a gap in tone presentation during the interval production, and participants were instructed to interrupt timing during the gap (see Fortin & Massé, 2000, for a detailed description of experimental trials in time production with gaps). Participants thus had to start timing at the beginning of the interval production, to interrupt timing during the gap in tone presentation, and then to resume timing after the gap until they judged that the target duration was reached. The interruption in tone presentation corresponding to the gap signal could occur 800, 1300 and 1800 ms after the beginning of the interval production; this is the gap location factor. The gap duration could be 2, 3 or 4 s. Values of gap location and gap duration varied within blocks of trials. Participants were told not to use counting or any other related strategies in order to support their time estimation.

Results and Discussion

Twenty-nine outliers (± 3 SD from the mean) were eliminated from the 5760 collected data. The data used for the analysis are mean produced intervals, not including gap duration, defined as the sum of pregap and postgap duration.

Figure 1 shows produced intervals as a function of gap location in two functions representing data from the experimental sessions 1 to 10 and from experimental sessions 11 to 20. The effect of gap location was present in the two groups of experimental sessions: produced intervals lengthened as the gap occurred later during the interval production. This effect of gap location, obtained in previous experiments, is attributed to 1) attention sharing between timing and monitoring for the gap signal (Fortin et al., 2005) and to 2) preparatory processes taking place before the gap (Bherer et al., 2007). Attention sharing would cause some loss in accumulating temporal information before the gap, which results in a lengthening of produced intervals. The loss in accumulation would be proportional to the duration preceding the gap occ-

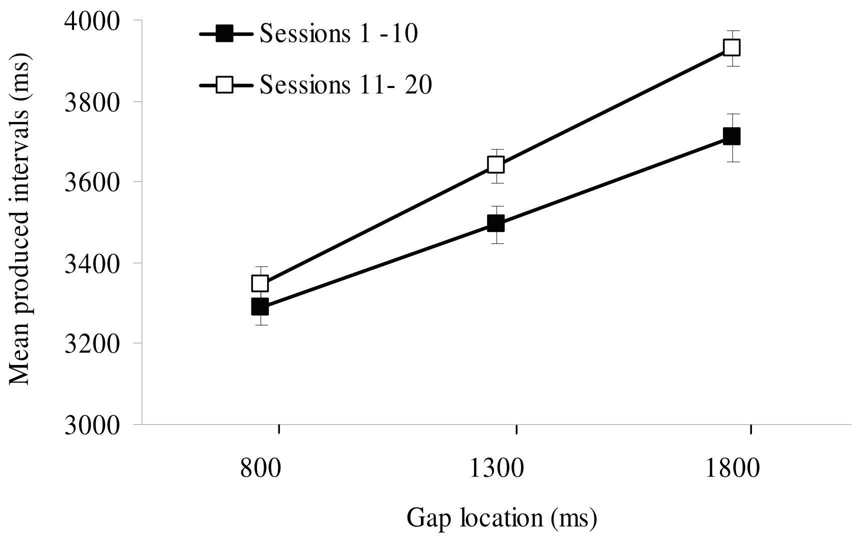

Figure 1. Mean produced intervals as a function of gap location, averaged over experimental sessions 1-10 and 11-20. Error bars are standard errors of the means.

urrence, hence the lengthening of produced intervals proportional to the value of gap location. Another factor responsible for the gap location effect is preparation to interrupt timing as soon as the gap signal occurs. This preparation, taking place during the pregap period, would allow participants to interrupt timing more quickly when the gap occurs later, in a way similar to the foreperiod effect in the reaction time literature (see Niemi & Näätänen, 1981). Interrupting timing more rapidly results in a relatively shorter perceived interval, hence the longer interval production.

Of particular relevance concerning the main objective of the present study, the slope relating produced intervals to location values was stronger in sessions 11 to 20 than in sessions 1 to 10, suggesting that the gap location effect increased with practice. This is confirmed in Figure 2, which shows the slopes of the functions relating produced intervals to gap location at each of the 20 successive experimental sessions, averaged over the two participants. Figure 2 shows that after the tenth experimental session, the slope values stabilized. A quadratic trend provides a satisfactorily description of the data (R^2 = .79). This trend was present in the data from each of the two participants (see Figure 3).

In contrast, the intercepts of the production functions remained unaffected throughout the 20 experimental sessions as shown in Figure 4. Coefficients of variation (CV = SD/mean) were computed for each participant, at each experimental session. The average of these CVs is presented in Figure 5. CVs seemed relatively unaffected by practice, although a slight general decrease in their values suggests that variability in time production with gaps tended to decrease with practice.

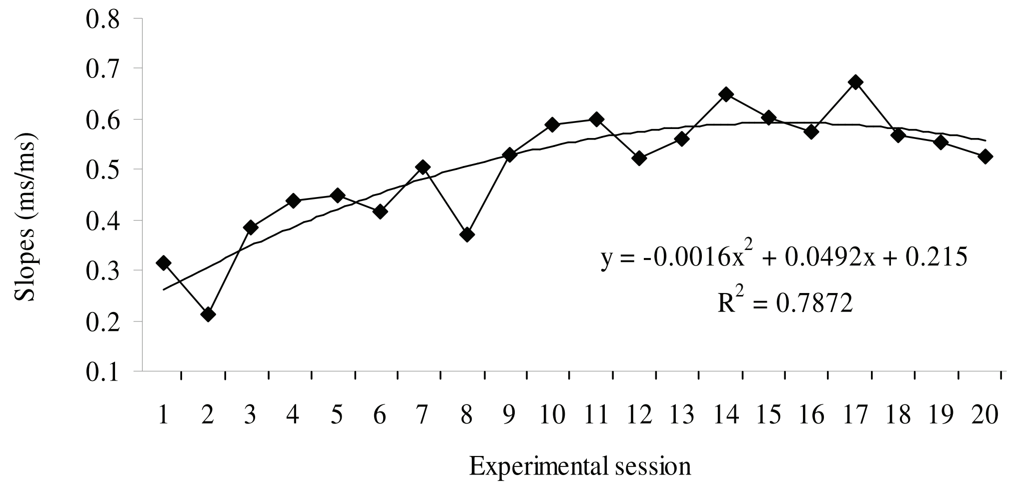

Figure 2. Slopes of functions relating produced intervals to gap location, at each experimental session.

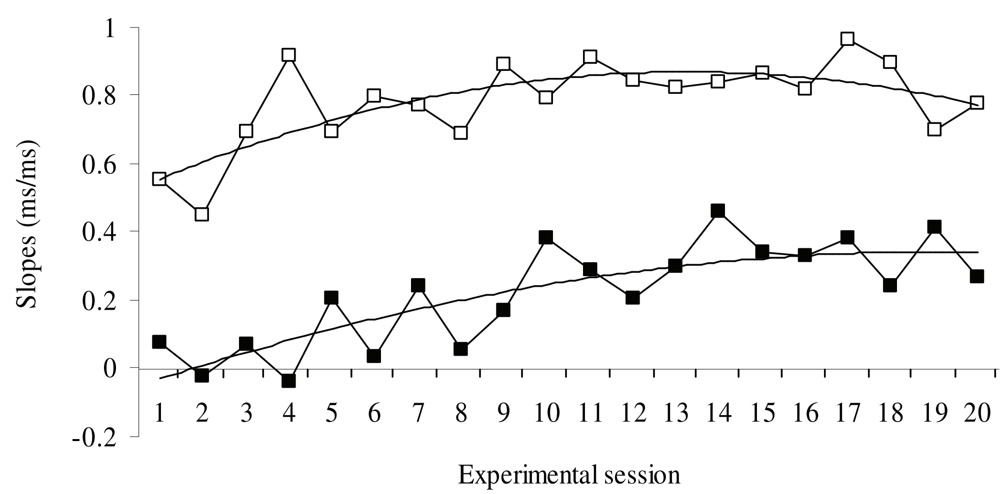

Figure 3. Slopes of functions relating produced intervals to gap location, at each experimental session, for each participant.

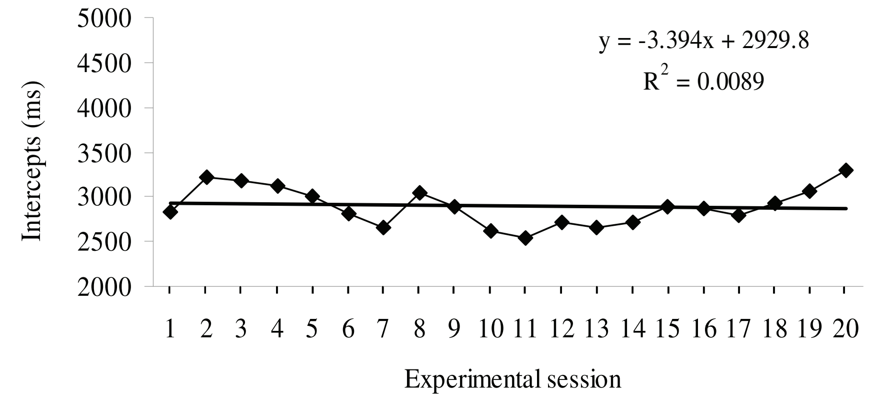

Figure 4. Intercepts of functions relating produced intervals to gap location at each experimental session.

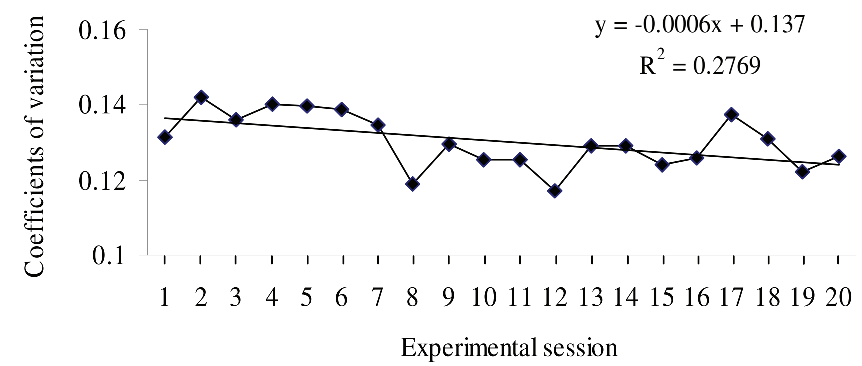

Figure 5. Coefficents of variation at each experimental session.

Table 1. Mean and Standard Deviation (SD) of time intervals produced with feedback in the first block of each experimental session

Session	Mean	SD	**Session**	Mean	SD
1	2465	288	**11**	2485	185
2	2446	209	**12**	2499	190
3	2529	251	**13**	2529	347
4	2559	271	**14**	2455	243
5	2512	245	**15**	2469	281
6	2487	297	**16**	2567	448
7	2524	207	**17**	2461	202
8	2464	198	**18**	2538	223
9	2500	204	**19**	2559	229
10	2509	235	**20**	2515	256

Taken together, the results of the present study suggest that practice affects specifically the processes taking place before the gap occurrence since the slopes of the production functions varied with practice. Intercepts of these functions were stable and CVs of produced intervals did not vary notably, suggesting that the representation of the target interval itself was not modified significantly by practice. Similarly, produced intervals in practice trials performed at the beginning of experimental sessions appeared to be unaffected by practice (see Table 1).

Previous studies suggest that two main factors are responsible for the effect of varying gap location in time production with gaps: attention sharing between timing and monitoring for the gap signal while it is expected during the pregap period (Fortin & Massé, 2000), and preparation to interrupt timing, which also takes place during the pregap period (Bherer et al., 2007). Attention sharing as well as preparation may have both contributed to make the effect of gap location vary in the present study. For example, practice may have increased the degree of certainty about the time of gap occurrence, influencing the amount or duration of attention sharing before the gap. Similarly, practice may have allowed the participants to better prepare to interrupt timing as soon as the gap signal occurs, thus increasing gradually the strength of the gap location effect in the first 10 experimental sessions. After a certain number of experimental sessions however, additional practice in trials with gaps would not increase further the degree of certainty concerning the possible values of gap location so that the gap location effect stabilizes. This would explain why, in the last 10 experimental sessions, the slopes of the functions relating produced intervals to gap location remained relatively stable.

Acknowledgments

This research was funded by grants from the National Science and Engineering Research Council (Canada) to C. Fortin and to Y. Lacouture.

References

Brown, S. W. (1998). Automaticity versus timesharing in timing and tracking dual-task performance. *Psychological Research, 61,* 71-81.

Brown, T. L., & Carr, T. H. (1989). Automaticity in skill acquisition: Mechanisms for reducing interference in concurrent performance. *Journal of Experimental Psychology: Human Perception and Performance, 15,* 686-700.

Bherer, L., Desjardins, S., & Fortin, C. (2007). Age-related differences in timing with breaks. *Psychology and Aging, 22*(2), 398-403.

Fortin, C., Bédard, M.-C., & Champagne, J. (2005). Timing during interruptions in timing. *Journal of Experimental Psychology: Human Perception and Performance, 31*(2), 276-288.

Fortin, C., & Massé, N. (2000). Expecting a break in time estimation: Attentional time-sharing without concurrent processing. *Journal of Experimental Psychology: Human Perception and Performance, 26*(6), 1788-1796.

Macar, F. (2002). Expectancy, controlled attention and automatic attention in prospective temporal judgments. *Acta Psychologica, 111*(2), 243-262.

Niemi, P. & Näätänen, R.(1981). Foreperiod and simple reaction time. *Psychological Bulletin, 89*, 133-162.

EXPLORATION OF THE FILLED-TIME ILLUSION WITH AN INTERVAL PRODUCTION TASK

Pierre-Luc Gamache, Nicolas Bisson, Lisa Hawke
Marie-Ève Roussel & Simon Grondin
École de psychologie, Université Laval, Québec, Canada

Abstract

The filled-duration illusion, or divided time illusion, refers to the fact that intervals filled with one or multiple intervening sensory events are perceived as being longer than undivided intervals of the same physical duration. The range of durations for investigating this illusion is most often restricted to very short durations (less than a second). Two experiments involving temporal production were conducted, in which participants used a finger-tapping method to produce series of .8- to 3-s target intervals (Experiment 1) or 1- to 1.4-s target intervals (Experiment 2). In Experiment 1, the addition of a divider leads to longer productions only in the short-target conditions but to shorter and more precise productions in the long-target conditions. In Experiment 2, the number of dividers varied from 0 to 3. The results showed that the constant error was larger at 1 than at 1.4 s and larger when more dividers were used, which is attributed to an increase in the information processing load.

The segmentation of temporal intervals can induce a bias in the evaluation of their duration. Indeed, a classical phenomenon called the “filled-time illusion” or “filled-duration illusion” refers to the fact that intervals filled with stimuli are perceived as longer than empty intervals of equal physical duration (Hall & Jastrow, 1886). Although this phenomenon has been investigated by several researchers (see ten Hoopen, Miyauchi, & Nakajima, in press), some questions remain unanswered, given the large number of parameters to consider with regard to this illusion (e.g. the type and the number of dividers, the duration range examined, the sensory modality marking time…).

Several solutions have been proposed to account for the observed overestimation of filled intervals (e.g. Adams, 1977; Nakajima, 1987; Thomas & Brown, 1974). For instance, Buffardi (1971) reported that the overestimation is directly due to the number of dividing sounds occurring during an interval. On the other hand, Nakajima’s (1987) model proposes a simple and straightforward solution: The magnitude of the overestimation is proportional to the number of subdivisions, plus a constant, which can be represented by the following formula:

$$\tau(t) = k(t + \alpha),$$

$\tau(t)$ being the subjective duration of a time interval as a function of its physical duration t, a scaling constant k, and a ‘supplementary’ constant, which would represent the mental time required to process the interval. The value of α is estimated at 80 ms (Nakajima, 1987). For example, if we apply this formula to an empty interval divided by 2 sounds (thus, 3 subintervals to process), the total perceived duration should be equal to k(t1 + 80ms) + k(t2 + 80ms) + k(t3 + 80ms) = k(t1 + t2 + t3 + 240ms). Suppose that we set k at 1 (k =1) for this example; we would then observe a 240 ms overestimation of the subjective duration compared to physical time, 160 extra ms being a direct consequence of the segmentation. While Nakajima did not do the test to validate this model, a close look at Buffardi (1971) reveals that the reported results provide support for this explanation (ten Hoopen et al., in press).

The purpose of the following experiments is to directly test to what extent the model proposed by Nakajima (1987) can predict the perceived duration of subdivided intervals from different duration ranges. We anticipated that the insertion of dividing signals would generate