Visual feedback is not important for bimanual human interval timing

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The influence of redundant visual feedback on bimanual human interval timing

The clock variance of intervals produced by one finger is reduced when that finger taps along with another finger (termed the bimanual advantage). The multiple-timekeeper model proposes a coupling of internal clocks, leading to reduced clock variance for bimanual timing. Alternatively, reduced variance for bimanual timing could result from additional sensory feedback from two fingers as opposed to one. We aimed to test the role of visual feedback in reducing temporal variability. Participants tapped unimanually and bimanually (with no table contact) in three conditions: full vision, blindfolded, and with additional visual feedback provided via a mirror reflecting the right hand. We predicted that temporal variability would be reduced for tapping with vision versus no vision, and when the left hand was represented by a mirror but did not actually tap. Additional, redundant visual information did not reduce temporal variability for any condition, suggesting that visual feedback is not crucial for bimanual advantage. These findings support the role of sensory feedback (namely, tactile, auditory, and proprioceptive) in reducing timekeeper variability during bimanual timing and argue against a strictly multiple-timekeeper model.

Keywords: interval timing; tapping; bimanual advantage; visual feedback; clock variance

1.1

Introduction:

Human-environment interaction requires both detection of external events and control of actions to interact with those events. As the limbs execute intended movements, the brain must compare predicted movement outcomes with actual outcomes, typically by way of feedback signals resulting from those actions. How well a person can utilize predictive mechanisms and feedback to control and adjust for errors in his/her movement is often examined via a repetitive timing task whereby a metronome prescribes a pace (~2 Hz) and a participant attempts to maintain this pace after the tones stop. A person's timing ability is often quantified as the variance of a series of produced interval durations. According to the classic timing model proposed by (Wing & Kristofferson, 1973a), two processes contribute to timing variability; an internal clock process measures out regular intervals, and a motor implementation process translates these signals to begin each tapping movement. Behavioral (Keele & Ivry, 1988; Keele, Pokorny, Corcos, & Ivry, 1985; Wing & Kristofferson, 1973a, 1973b) and neurological evidence (Ivry & Keele, 1989; Ivry, Keele, & Diener, 1988) supports the independence of the clock and motor components of timed movement.

When executing repetitive movements, such as continuous tapping, especially when the goal is to produce movement that is synchronous with external events (e.g., a metronome), the role of feedback is crucial (Drewing, Stenneken, Cole, Prinz, & Aschersleben, 2004; Studenka & Zelaznik, 2011). Tapping intervals made without access to tactile or proprioceptive feedback (deafferented participants) exhibited poor synchrony with a metronome (Drewing et al., 2004). Furthermore, several researchers have argued that a documented improvement in timing with two fingers over one results from the additional feedback received by the second finger (Drewing & Aschersleben, 2003; Drewing, Hennings, & Aschersleben, 2002; Drewing et al., 2004). Bimanual advantage refers to the reduction in total, and sometimes clock, variance of intervals produced by one finger when that finger taps together with another finger, typically on the opposite hand (Drewing & Aschersleben, 2003; Drewing et al., 2002, 2004; Helmuth & Ivry, 1996). Several explanations for this reduced variability exist, namely the multiple-timer model hypothesis and a sensory feedback hypothesis.

According to the formalized "multiple timer model" (Ivry & Richardson, 2002), a separate clock signal is generated for each effector (e.g., the right and left index fingers), and these clock signals are combined prior to initiation of movement. This coupling, or gating, process also serves to initiate the next clock signal in the series of repetitive timed movements. Helmuth & Ivry (1996) cited reduced variability of timed intervals when both hands were used, compared to when only one hand was used, and attributed this to the central (clock) as opposed to the motor implementation component of variability. Behavioral data support that coupling timing variability for two hands approximates an average of the two independent timing signals (Helmuth & Ivry, 1996). The resultant variability of two averaged clock signals is smaller than that of one signal alone, resulting in reduced variability at the motor output level of timed movement.

An alternate or additional explanation for the bimanual advantage posits that timing improves as a result of additional sensory feedback received when two effectors time instead of one. The feedback hypothesis is supported by several studies showing that changing feedback to a finger on one hand influences timing variability in the opposite hand. During bimanual timing, a reduction in tactile feedback to a participant's left finger (contact-free) increased overall clock variance in right finger tapping compared to when both hands had tactile feedback from taps (Drewing et al., 2002). In another study, when auditory feedback was present for only right-hand taps, the bimanual advantage was not as strong as when both hands received auditory feedback from taps (Drewing & Aschersleben, 2003). Furthermore, a significant multi-effector advantage was seen when the index and middle finger from one hand, versus only the index or middle finger, were used to time intervals, suggesting that bimanual advantage is a phenomenon of multiple, time-related feedback signals (Drewing et al., 2002) rather than multiple clocks. Increasing sensory information about one timing goal acts either to improve detection of timing error via direct feedback mechanisms and online corrections, or to improve prediction of future movement goals via an "averaging" of feed-forward or predictive control signals (see Drewing & Aschersleben, 2003).

In order to fully understand the role of feedback in timing, and, in particular in bimanual timing, the unique role of vision as a source of feedback must be tested separately from tactile, proprioceptive, and auditory feedback. Although it may seem obvious that vision plays a minor role in timing, particularly with one finger (see Repp & Penel, 2002, 2004; Repp, 2005) and therefore would play a minor role in bimanual timing, this notion has never been empirically tested. It is well documented that synchronizing movement of just one hand to a visual metronome leads to greater variability; however, variability in timing did not significantly differ for tapping with and without visual feedback (Chen, Repp, & Patel, 2002; Repp & Penel, 2004). Furthermore, in a unique circumstance, for a participant with sensory fiber peripheral neuronopathy, tactile, auditory, and kinesthetic feedback from taps were not available, however, a significant bimanual advantage was seen indicating that visual information (the only type of feedback this participant had access to) was sufficient to elicit better timing with two than with one finger (Drewing et al., 2004).

Furthermore, in studies supporting the theory that multiple feedback signals enhance timing ability, a multiple-timekeeper theory cannot be entirely ruled out because two effectors (and therefore two clocks) are employed in addition to multiple or enhanced feedback signals. Drewing et al. (2002) attempted to control for multiple timekeepers by having participants tap two fingers from the same hand (assuming multiple sources of feedback, but not multiple clocks), however, this paradigm does not rule out the possibility of unique timers existing for each finger (even on the same hand). Furthermore, a significant bimanual advantage in an individual with no tactile or proprioceptive sensation points to a theory of timing not dependent on feedback from movement (Drewing et al., 2004).

Based on these theories of both unimanual and bimanual interval timing, and the lack of investigation into the specific role of visual feedback in interval timing and the bimanual advantage, we set out to investigate the influence of multiple visual feedback signals on bimanual interval timing. Our first aim was to test the extent of bimanual advantage both with and without vision for tapping with reduced tactile, proprioceptive, and auditory feedback about taps. We hypothesized that, if vision is important for temporal consistency, bimanual advantage would be present and greater for tapping with vision than without vision. Our second aim was to test the influence of additional visual feedback on timing by having participants tap next to a mirror (representing the other hand). If timing variability in the right hand is decreased when the left hand is represented by a mirror, but does not actually tap, the sensory feedback hypothesis for the bimanual advantage will be supported. Support of this hypothesis will also lend evidence against the multiple-timekeeper theory of bimanual advantage. Alternately, if bimanual advantage does not occur when the left hand is represented by a mirror but does not actually tap, the multiple feedback signal theory for bimanual advantage will not be supported.

We controlled the influence of tactile feedback by having participants tap into the air. Furthermore, we aimed to reduce the influence of proprioceptive feedback by having participants end taps before the finger reached full flexion. Tapping to full flexion (a joint angle extreme) may provide feedback about when a movement reversal occurs (see Proske, Schaible, & Schmidt, 1988 for a review). Additionally, the skin receptors in the finger can provide information about movement that might aid timing, particularly at extreme positions which include more stretch of the skin (Collins, Refshauge, Todd, & Gandevia, 2005). In order to test the effect of additional visual feedback, in one condition, we placed a mirror between the right and left hands occluding vision of the left hand while providing a mirror reflection of the right hand. For this condition, participants had access to two visual signals representing the same tap.

2.1

Method:

2.1.1

Participants:

Thirty participants were recruited. One participant did not complete the experiment. One participant exhibited only one trial that fit the Wing & Kristofferson model for event-timing, and was therefore removed from analysis. One participant closed his eyes during the experiment, and one participant was outside of our age range for testing (18-30). The final dataset, therefore included 26 right-handed participants (15 male, 11 female) with a mean age of 21.3 years. Informed consent procedures were approved by the Utah State University Institutional Review Board (IRB; approval number 5001).

2.1.2

Apparatus and Tasks:

Each participant was seated at a 75 cm high table. Each participant rested each hand on top of a platform with two square cutouts, 40 cm apart (see Figure 1). Vicon (VICON Motion Systems, Oxford, UK) reflective markers (14 mm) were placed on the styloid process of the ulna, the styloid process of the radius, the head of the 2nd metacarpal, and the tip of the 2nd distal phalange of each participant's right and left hand. An additional marker was placed near the base of the 3rd metacarpal on each participant's left hand in order for the Vicon Nexus software to be able to distinguish the right from the left hand. Each participant performed three tasks both unimanually and bimanually. Tapping was performed with a blindfold on, with full vision while fixating between two crosses placed directly between the two hands, and while fixating between the crosses with the left hand occluded by a mirror. The visual angle from center to each index finger was approximately 11 degrees. For each tapping trial, participants were instructed to tap to the "level of the platform", and not to contact the sides of the cut-out squares. Additionally, participants were instructed to end taps before they reached maximal flexion. For the mirror tapping condition, a mirror was placed between the two arms so that vision of the right arm through the mirror appeared in the same location as the resting left arm. For mirror tapping conditions, the participant could not see the left arm.

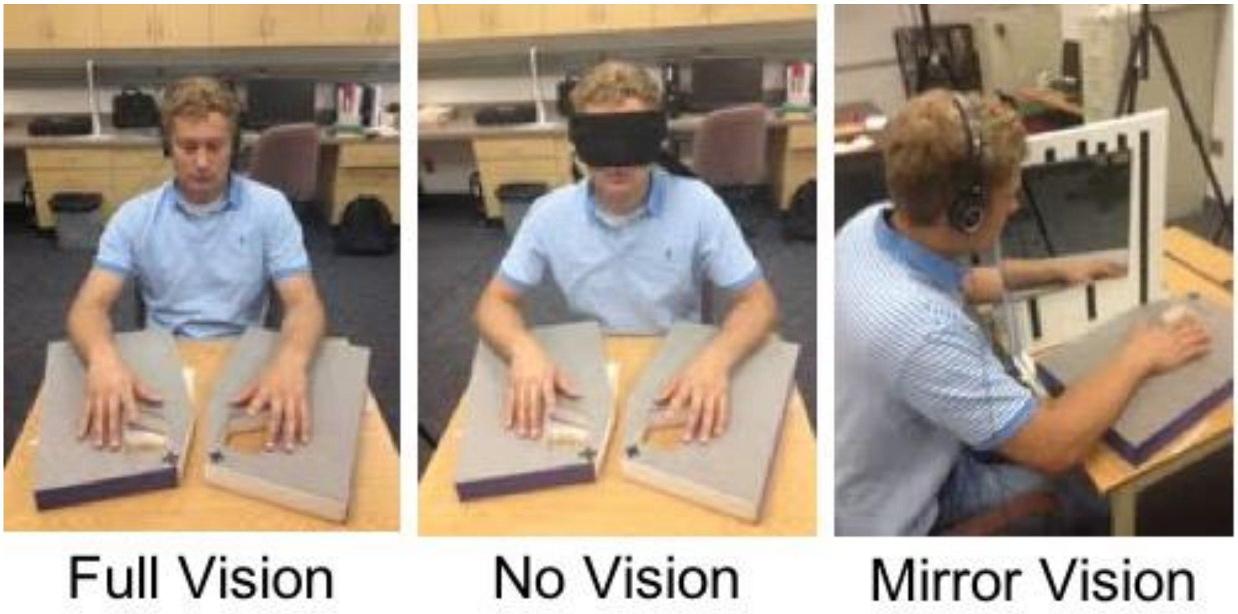

Figure 1. Picture of the task set up for full vision, no vision, and mirror vision tasks. Reflective markers are not depicted here.

For all trials, a metronome sounded for ten tones spaced 800 ms apart. A participant attempted to complete each tap (complete the flexion movement) coincident with the metronome tones (10 ms, 717 Hz). When the metronome stopped, the participant was instructed to continue to move at the prescribed pace (25 additional seconds) until another, higher pitched tone sounded (550 ms, 860 Hz). Noise canceling headphones (Sennheiser HD 200) were worn for all trials.

2.1.3

Procedure:

The experimenter greeted the participant, the experiment was explained, and consent was obtained. After being seated, Vicon markers were placed on both hands, and the Nexus software was used to uniquely calibrate the model for each hand. Each participant performed 10 trials of each task and condition. The task by condition blocks were counterbalanced so that each participant performed them in a different order. Each trial consisted of 10 intervals (800 ms) of synchronization followed by approximately 30 additional taps. Following the completion of a trial, the participant was reminded of the timing goal and provided the mean of his/her own performance. If the participant’s mean interval duration was above 825 ms or below 775 ms, the experimenter reminded the participant to stay on pace. After completion of each task, a participant rested until he/she felt ready to continue. The experimental session lasted approximately 45 minutes.

2.1.4

Design:

Two comparisons were relevant. First, bimanual timing with and without visual feedback were compared. Second, tapping in three tasks (full vision, no vision, and mirror vision) and 3 conditions (right unimanual, right bimanual, and left bimanual) were compared. Statistical comparisons were performed using SAS version 9.4 with significance level set to .05 unless otherwise stated. ANOVAs were performed using PROC GLM, and contrasts within task were performed using specific contrast statements within the main ANOVA. The order of tasks and conditions was counterbalanced using a Latin square design to control for effects of learning and familiarization. We did not have participants perform the conditions with their left hand as this would have make the experimental duration well over 90 minutes, and we have found that participants lose focus and do not perform as well after 60 minutes.

2.1.5

Data collection and reduction:

Kinematic data were collected via the Vicon Nexus Bonita motion capture system at 250 Hz and fed into custom written, Matlab software that utilized the real-time positional data from the Vicon Nexus software (Nexus SDK toolbox). Inter-stimulus intervals were calculated using a custom-written code that identified the time points at which a participant's finger reached maximal downward flexion. The algorithm determined the maximal velocity in the downward direction and, subsequently found the point at which the finger reached 3% of maximal velocity (nearly 0 velocity). These points were recorded, and the series of interval durations were calculated by finding the difference between these points. Data were only collected during continuation (after the metronome turned off). This series of cycle durations was linearly detrended removing any within-trial drift. Total variability in a time series of tapping intervals (V) reflects the variability of both clock (C) and Motor (M) processes ($V = C + 2M$). Owing to the assumption that clock and motor variance are independent, the inverse of the covariance of a time series of tapping intervals with this same time series lagged by one has been used as an approximation of the motor variance (see Wing & Kristofferson, 1973a). Following this, the variability of the clock is calculated as twice the motor variance subtracted from the total. Averages and variances for cycle durations were calculated for every trial and then averaged over the best 8 of 10 trials for each task based on the coefficient of variation (standard deviation / mean * 100). It is common practice in the analysis of tapping intervals to use the "best" rather than all trials under the assumption that the best trials represent more pure timing (e.g., unaffected by lapses in attention etc.; see Robertson et al., 1999; Zelaznik, Spencer, & Ivry, 2002; Zelaznik et al., 2012). Values for clock and motor variance were calculated based on the (Wing & Kristofferson, 1973a) derivations and later modifications proposed by (Vorberg & Wing, 1996). Only trials that exhibited a lag one autocorrelation between 0 and -.5 were used for the final analysis of clock and motor variance. A total of 14 of 1858 total trials were excluded from analysis and no more than 2 were excluded for any individual condition and participant.

3.1

Results:

Our first aim, to test the bimanual advantage with and without vision for tapping with reduced tactile and proprioceptive feedback was addressed using the dependent variable of coefficient of variation. A three condition (left bimanual, right unimanual, and right bimanual) by three task (full vision, no vision, and mirror vision) ANOVA was run. Assumptions for normality were not met (Shapiro-Wilk, W = .84, p < .0001), and, therefore data were transformed using a log10 transformation yielding a non-significant Shapiro-Wilk (W = .99, p = .09). Levene's test indicated equal variances for task (F = .50, p = .61), condition (F = 1.74, p = .18), and the task by condition interaction (F = .71, p = .68). Mauchly's test indicated that the assumption of sphericity had been violated for condition ($\chi 2(2) = 13.13$, p = .001), and the task by condition interaction, ($\chi 2(9) = 32.39$, p = .0002) therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.70$; $\varepsilon = 0.66$).

We did not see a bimanual advantage (lower variation for right unimanual than right bimanual timing) in any task, regardless of the addition, reduction, or manipulation of visual feedback (see Figure 2). A significant task effect F (2, 50) = 6.23, p = .005, $\eta_p^2 = .20$ revealed an overall larger coefficient of variation for the no vision task (6.03) vs. the full and mirror vision tasks (5.45, 5.73); F (1, 50) = 11.46, p = .001, $\eta_p^2 = .19$. No significant condition effect, F (1.4, 35) = 2.69, p = .10, or task by condition interaction was seen, F (2.64, 66) = .72, p = .53. In order to test our second hypothesis, that the addition of a visual feedback signal would reduce timing variability, an a-priori contrast between unimanual tapping with full visual feedback and unimanual tapping with mirror visual feedback was performed. This contrast was not significant, F (.66, 66) = .03, p = .87.

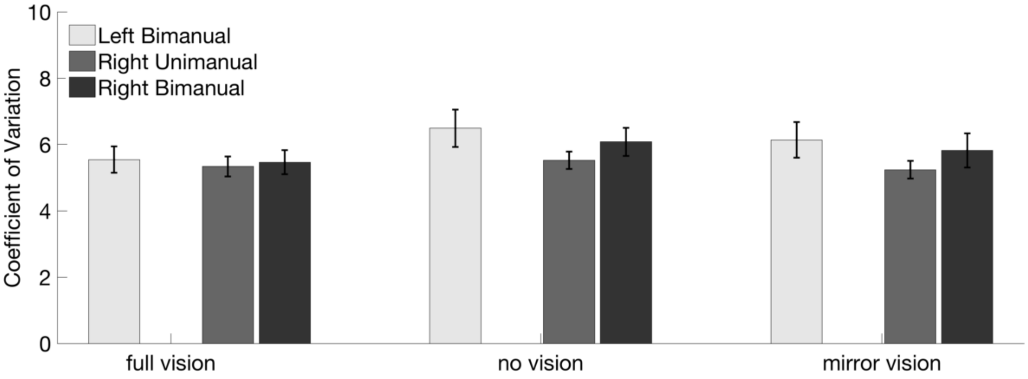

Fig.2 Coefficient of variation for right unimanual and both right and left bimanual timing for full vision, no vision, and mirror vision tasks. No vision exhibited greater coefficient of variation than the other conditions. Error bars represent the standard error.

Bimanual advantage has also been examined using clock variance, with significant decreases in clock variance exhibited for timing with two versus one effector (e.g., Studenka, Eliasz, Shore, & Balasubramaniam, 2014). Assumptions for normality were not met (Shapiro-Wilk, W = .67, p < .0001), and, therefore data were transformed using a log10 transformation yielding a non-significant Shapiro-Wilk (W = .99, p = .03). Levene's test indicated equal variances for task (F = .99, p = .37), condition (F = .50, p = .61), and the task*condition interaction (F = 1.27, p = .26). Mauchly's test indicated that the assumption of sphericity had been violated for condition ($\chi 2(2) = 8.90$, p = .01), and the task by condition interaction, ($\chi 2(9) = 30.32$, p = .0004) therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.76$; $\varepsilon = 0.68$).

Clock variance exhibited similar results to the coefficient of variation in that no significant bimanual advantage was seen (condition main effect, *F* (1.52, 38) = 1.60, *p* = .21; see Figure 3). There was no significant task effect, *F* (2, 50) = .27, *p* = .77, and no significant task by condition interaction, *F* (2.24, 56) = .84, *p* = .47. There was no difference between unimanual right hand timing in the full vision and mirror vision conditions, *F* (.68, 68) = .50, *p* = .48. Furthermore, an a-priori contrast showed that there was no difference between unimanual right hand timing in the full vision and no vision conditions, *F* (.68, 68) = .21, *p* = .65.

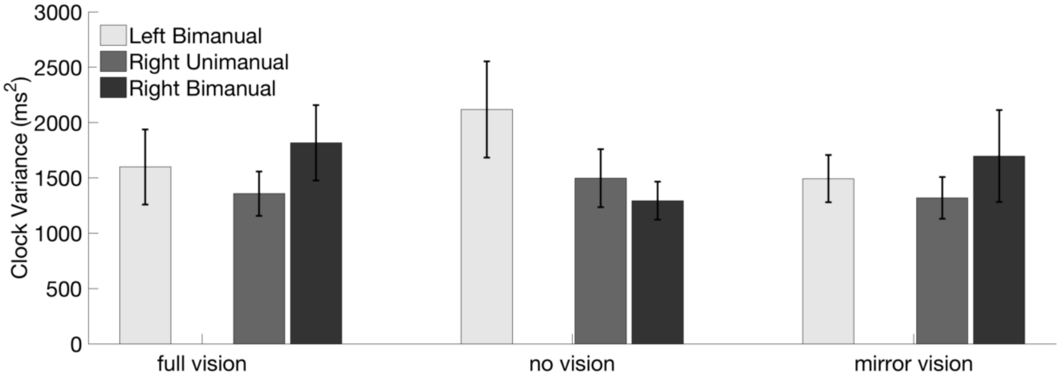

Fig.3 Clock variance for right unimanual and both right and left bimanual timing for full vision, no vision, and mirror vision tasks. No significant differences were seen. Error bars represent the standard error.

Due to the finding that no bimanual advantage was seen, a power analysis was performed on the condition effect for both coefficient of variation and clock variance to ensure that the study was appropriately powered and that the finding of no difference was not dependent on the sample size of 26 subjects. Post-hoc power analysis was performed using G*power (version 3.1; cite) for the repeated measured within factor of condition (bimanual vs. unimanual conditions). The computed power for coefficient of variation was .96 and the computed power for clock variance was .79. We are therefore, confident that our findings reflect a truly non-significant effect of vision on the bimanual advantage.

4.1

Discussion:

Myriad research documents a bimanual advantage when two hands tap instead of one (Drewing & Aschersleben, 2003; Drewing et al., 2002, 2004; Helmuth & Ivry, 1996; Ivry & Richardson, 2002; Studenka et al., 2014). In every one of these studies, either tactile or auditory feedback from taps (or both) was available and potentially of use for synchronization and timing. Although we did not directly test for the bimanual advantage in our participants using the typical table tapping task, based on the body of work showing bimanual advantage for tapping, we reasonably conclude that feedback – particularly auditory and tactile – is important for the bimanual advantage. Our findings paired with research showing bimanual advantage for tapping supports the feedback hypothesis over the multiple-timekeeper hypothesis for bimanual advantage specifically because the multiple timekeeper model of bimanual advantage predicts that the averaging of two clock signals (regardless of feedback) will lead to reduced temporal variability. The lack of bimanual advantage when only visual feedback was provided is likely due to the elimination of tactile and proprioceptive feedback that resulted from the requirement for participants to tap to the level of the surface, rather than to full flexion. These findings support other work showing that eliminating tactile feedback reduced bimanual advantage (Drewing et al., 2002). Only one other study, to our knowledge, has exhibited no bimanual advantage with eliminated tactile feedback (Studenka et al., 2014). In both the current study and the Studenka et al., 2014 study, proprioceptive feedback gained from tapping to full flexion was reduced by having participants tap only to the level of the table. At joint angle extremes, as in tapping to full flexion, proprioceptive, joint and skin receptors may give information related to when a tap has ended that are subsequently utilized by the clock mechanism to reduce timing when two fingers move compared to only one (Proske et al., 1988). It was the case for one patient with sensorimotor peripheral neuronopathy that visual information was enough to elicit the bimanual advantage (when audition was removed), but one could argue that this was a function of re-weighted reliance on visual information to perform every-day tasks due to his condition (Drewing et al., 2004). In a study using college-aged participants, spatial, but not temporal characteristics of timing were impaired by the elimination of visual feedback (Zelaznik & Lantero, 1996), furthering the argument that visual feedback plays only a minor role in timing (see also Kolers & Brewster, 1985; Repp & Penel, 2002, 2004).

Our hypothesis that an additional source of visual information would aid timing for unimanual tapping was not supported as there was no reduction in unimanual timing variability when the additional source of visual feedback was added via the mirror. This might be a result of the minor role of visual feedback in timing in general, or because the additional source of visual feedback used was redundant timing information. In other studies on the bimanual advantage, additional sources of temporal information have been from two different modalities (e.g., tactile and auditory), for example, when auditory feedback was added to taps, temporal variability for both unimanual and bimanual tapping decreased (Drewing & Aschersleben, 2003). The most likely explanation for no reduction in variability due to additional mirror feedback is a minor reliance on visual feedback for temporal information (see Repp & Penel, 2002, 2004), as there was also no increase in unimanual variability when vision was removed. It is also important to note that the visual information provided to participants in the current study was in the periphery as focus was kept at a mid-point between the two hands. It could arguably be the case that, because vision was in the periphery and not in central vision, participants did not receive temporal information from the fingers, and therefore, were not able to utilize it. Several studies, however, support the role of peripheral vision for temporal (as opposed to spatial) processing. The fovea (central vision) is able to process fine spatial information, and perhaps processes spatial information separately from temporal information. Peripheral vision, however, was found to be more sensitive to temporal aspects of motion (Hartmann, Lachenmayr, & Brettel, 1979; Mckee & Nakayama, 1984). Hartmann et al. (1979) found that the critical flicker frequency (the frequency at which a flickering light is indistinguishable from a steady, non-flickering light) was greater in visual peripheral versus foveal vision up to about 30 degrees, indicating that temporal information is perceived well within near peripheral vision.

Additional visual information may provide a different source of temporal information if kept within central vision. Testing of that hypothesis was not within the scope of this study, but would be a promising avenue for future research on vision and timing.

It may also be the case that another form of visual feedback would elicit a bimanual advantage. Although some research indicates that participants synchronize better with visual signals that are more similar to the tapping movement (e.g., a continuous visual signal moving up and down; Hove & Keller, 2010; Hove, Spivey, & Krumhansl, 2010), other research indicates that an absence of a discrete events in a cycle of movement leads to poor synchronization (see Elliott, Welchman, & Wing, 2009; Studenka & Zelaznik, 2011). Hove, Spivey, & Krumhansl, (2010) had participants synchronize dominant hand tapping to four different visual metronomes in addition to an auditory tone. The visual metronomes were a visual flash (a discrete signal similar to an auditory beep), a video of a two-dimensional bar that move up and down continuously, a video of a rotating bar that rotated up and down, similar to the biological motion of a finger moving about the knuckle joint, or a video of a finger tapping. The authors found that the variability in synchronization was better with a continuously moving signal rather than a discrete one (see also Hove & Keller, 2010). In the research involving the comparison of different visual metronomes, tapping was always to a table-top and therefore contained motor-related events. It could be that, in the current experiment, eliminating the auditory and tactile feedback from touching a surface and the proprioceptive and sensory feedback from not tapping to full flexion also eliminated a crucial element for synchronization; the presence of events. It is possible that adding a source of visual feedback that represents the timing goal (e.g., a discrete flash when the finger passes through the level of the table top) might aid synchronization by adding a sensory (rather than a motor) event. In support of this hypothesis, Zelaznik & Rosenbaum, (2010) showed similar timing for two different motor tasks when the sensory goal (to produce a click) was the same. It therefore, may be the unique interaction between the type of movement, feedback from the movement, and the presence of sensory and motor events that dictate the extent to which timing is aided by moving with two versus one effector.

These findings provide the first evidence that, when tactile, proprioceptive, and auditory sources of information are greatly reduced or removed, vision plays a minor role in timing, and, in particular, that additional sources of redundant visual information alone are not helpful in reducing temporal variability. In other words, additional sources of visual feedback (e.g., playing music in front of a mirror) may not have the same effect as additional sources of tactile and or auditory feedback. Evidence suggests that additional, non-redundant sources of movement and/or temporal information (e.g., tapping your foot while playing music) lead to reduction in temporal variability. This was not the case in our study, using solely visual information as the additional source of temporal feedback. This may be due to the well documented phenomenon that visual feedback is less useful regarding temporal information than auditory or tactile feedback (see Repp, 2005). The role of visual information in aiding control of consistently produced movement is still not entirely clear. This study, however, provides strong support that feedback (in particular tactile, auditory and proprioceptive feedback) is important for the bimanual advantage and that even multiple sources of visual feedback do not aid timing in the same way as other sources of feedback about timing goals.

Figure Captions:

Fig.1 Figure 1. Picture of the task set up for full vision, no vision, and mirror vision tasks. Reflective markers are not depicted here.

Fig.2 Coefficient of variation for right unimanual and both right and left bimanual timing for full vision, no vision, and mirror vision tasks. No vision exhibited greater coefficient of variation than the other conditions. Error bars represent the standard error.

Fig.3 Clock variance for right unimanual and both right and left bimanual timing for full vision, no vision, and mirror vision tasks. No significant differences were seen. Error bars represent the standard error.

Compliance with Ethical Standards:

Funding: This study was not funded by any external source.

Conflict of Interest: Author Studenka declares that she has no conflict of interest. Author Cummins declares that she has no conflict of interest. Author Myers declares that she has no conflict of interest.

Ethical approval: This article does not contain any studies with animals performed by any of the authors. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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