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When meditators avoid counting during time production things get interesting

Joseph Glicksohn,[1,2] and Aviva Berkovich-Ohana[3]

[1]Department of Criminology, Bar-Ilan University, Ramat Gan, Israel, [2]The Leslie and Susan Gonda (Goldschmied) Multidisciplinary Brain Research Center, Bar-Ilan University, Ramat Gan, Israel, [3]The Edmond J. Safra Brain Research Center for the Study of Learning Disabilities, Faculty of Education, University of Haifa, Haifa, Israel

Abstract: Time production (TP) with or without chronometric counting both instantiates and reflects the working of an internal clock, as originally posited by Treisman. We exploit the fact that a number of experienced meditators, who had previously participated in a study wherein TP was assessed, and who had employed chronometric counting then, would be coming back to the lab to participate in a second study. We specifically requested that they should not employ chronometric counting this time, thus allowing us to contrast TP with and without counting. We report a qualitative difference between TP implemented by counting and TP without counting: The first is a linear function of target duration (T), while the second is not, and entails a discontinuity in the function. Requesting meditators not to engage in chronometric counting, and thereby forcing them to rely instead on other cues (sensory, bodily, etc.), might well be an appropriate context in which to observe such a discontinuity in TP.

Keywords: chronometric counting; internal clock; meditation; mindfulness; time production

Correspondence to: Professor Joseph Glicksohn, Department of Criminology, Bar-Ilan University, Ramat Gan 52100, Israel. Email: jglick@post.bgu.ac.il

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Meditation, meditators, and time perception

There is a consensus in the literature that meditation (however defined and practiced) is a *state* conducive to an expanded awareness of time (i.e., a subjectively experienced *slowing down* of time) and, perhaps, a corresponding slowing down of the internal clock. Both of these propositions appear in our own previous work (Glicksohn, 2001), and, to some extent, also in the work of others (e.g., Droit-Volet, Fanget, & Dambrun, 2015; Wittmann et al., 2015). Nevertheless, a reviewer of a previous draft of this paper has insightfully written as follows: "I agree with the idea that meditation conducts to an expanded awareness of time but there is no consensus relating to awareness of time and slowing down of the internal clock." Indeed, in a previous paper (Glicksohn & Lipperman-Kreda, 2007, p. 295), in discussing nitrogen narcosis, we addressed this very issue, raised by a similar comment. The two positions, therefore, seem to be as follows: (1) A general "slowing down," including an expanded awareness of time, *necessarily* implicates a slowing down of the internal clock (Glicksohn, 2001; note, the converse would also hold for a general "speeding up"); (2) the general "slowing down" does not necessarily implicate the slowing down of the internal clock, because it is "important to distinguish between the explicit awareness of time and the direct perception of time. A disturbance in the former does not systematically imply a disturbance in the latter" (Droit-Volet, 2013, p. 260), and because "there is a recalibration of this clock over time" (Droit-Volet, 2013, p. 262). This seems to be a topic worthy of future research. Note that performance on a time production task, as employed in this study, is commonly assumed to reflect the speed of the internal clock (Glicksohn, 2001; Ozel, Larue, & Dosseville, 2004; Pouthas & Perbal, 2004).

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A complementary notion is that for experienced meditators, whose baseline resting state will look suspiciously like a meditative state (Tei et al., 2009), it is their *trait* that is conducive to these very same predictions. This is what we have found in our previous work (Berkovich-Ohana, Glicksohn, & Goldstein, 2011, 2012), and this is the conclusion drawn by Droit-Volet et al. (2015, pp. 86–87) when reviewing our work, though these authors have suggested that there is no such slowing down of the internal clock, because "the internal clock is recalibrated over time" (p. 87).

To elaborate on that, as a trait, one dominant characteristic of the meditator is the deliberate and continuous focus of attention on the present moment. The propensity of focused awareness on an object as trained in meditation relates to a more mindful experience in the present moment and a subjective slowing of time (Kabat-Zin, 2005; Wittmann, 2016). It was previously suggested that meditative practices induce a change in subjective temporal experience towards emphasizing the "now," or being less aware of the passage of time (D. Brown, Forte, & Dysart, 1984). This can be measured as longer time production (indicative of a slower rate of functioning of the internal timer), demonstrating that internal time seems to be moving slower (Glicksohn, 2001). In agreement with that, longer subjective time units were shown in Mindfulness Meditation practitioners compared to control participants (Berkovich-Ohana et al., 2011). In later studies, control participants as well as experienced meditators showed a relative time expansion for stimuli in the millisecond-to-second range directly after a mindfulness meditation session (Droit-Volet et al., 2015; Kramer, Weger, & Sharma, 2013). Recent cross-sectional studies comparing experienced meditators with meditation-naive controls in the ability to judge duration showed how subjective time in everyday experience is slowed in mindfulness meditators (Wittmann et al., 2015) while the accuracy in time perception is increased in Transcendental Meditation practitioners (Schötz et al., 2015).

One limitation of our previous work that might be raised is that the mindfulness meditators employed chronometric counting when performing the time production (TP) task. Other researchers are very careful in either requiring their participants (meditators and controls) not to count (e.g., Droit-Volet et al., 2015) or in employing a procedure designed to prevent counting (e.g., Wittmann et al., 2015). The benefit of counting is, of course, in the fact that participants will be adopting a common strategy in their performance of time production (and we shall be returning to discuss this particular task in due course), hence some degree of experimental control is enforced. This advantage has been stressed by various authors in the literature (e.g., Coelho et al., 2004; Perbal, Droit-Volet, Isingrini, & Pouthas, 2002). Other authors have, however, argued that the last thing one would want to have in a study looking at time perception is for the participants to count (Wearden, Denovan, Fakhri, & Haworth, 1997; Wittmann & Paulus, 2008). Nevertheless, counting is a natural strategy to employ. And as Fetterman and Killeen (1990) argue: "The ubiquity of the practice calls into question experimental psychologists' attempts to prevent or interfere with subjects' counting strategies as a means of eliciting 'uncontaminated' temporal judgments" (p. 766).

Counting is undeniably in itself a timing task (S. W. Brown, Collier, & Night, 2013); furthermore, techniques used to prevent counting may "be distracting and introduce extraneous variables that can obscure effects specifically related to timing mechanisms" (Gaudreault & Fortin, 2013, p. 598). Chronometric counting is a strategy naturally employed by our experienced meditators (Berkovich-Ohana et al., 2011, 2012) when producing durations, hence they need not utilize their unique meditative experience and their mindfulness trait to engage in this task. When asked specifically not to count, however, their meditative expertise should be put to good use. From our reading of the literature, we have gained practically no insight into what participants do exactly when asked not to engage in chronometric counting. Experienced meditators who "are more strongly aware of sensory events" (Wittmann & Schmidt, 2014, p. 202) and who "provide more accurate introspective reports than novices" (Fox et al., 2012) should be able to provide us with such insight.

Time production and its analysis

In line with Treisman's (1963) "internal clock" model for time perception, a target duration (**T**) corresponds to a specific number of stored pulses, which is subsequently used to decide when to delimit the unfolding of this duration, resulting in the produced (**P**) duration. This is the task of TP, which can be accomplished with eyes closed or with eyes open. For example, this could be accomplished by listening to a filled interval of music with a clear offset, with the response being to press a button when the target

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interval appears to have elapsed—**P** being recorded to a high degree of accuracy. As Zakay (1993) writes, **P** is based on a "predetermined number of subjective time units which are associated in one's mind with the required objective time" (p. 93). Or, as Gibbon, Malapani, Dale, and Gallistel (1997) write, this decision is based on "the ratio of a currently evolving interval to a remembered standard" (p. 171).

The power function (H. Eisler, 1976) relating **P** to **T** is given by $\mathbf{P} = a\mathbf{T}^{\beta}$, linearized as $\log(\mathbf{P}) = \log(a) + \beta\log(\mathbf{T}) = \alpha + \beta\log(\mathbf{T})$. If **P** is veridical, then $\alpha = 0$, and $\beta = 1$. When $\alpha \neq 0$, there is a consistent bias in producing durations; when $\beta \neq 1$, then the untransformed data are not consistent with a linear function. We focus on four measures: (1) the slope (β) of the line, equivalent to the exponent of the power function, which might be veridical ($\beta = 1$; Allan, 1979), but more probably converges on the value of 0.9 (H. Eisler, 1976; Grondin, 2001); (2) the intercept (α) that is equivalent to the log-transformed measure constant of the power function; (3) the coefficient of determination (r^2) for the regression, which indicates the degree to which a linear fit to the data can be supported; and (4) mean log(**P**). While the data can be analyzed at the group level, it is patently clear that individual differences abound (Allan, 1983; Fraisse, 1984; Zakay, 1990); hence the computation of individual regression equations is mandatory (Glicksohn & Hadad, 2012).

The power law is expected to hold, assuming that the individual is not in fact counting. We stress, however, that while a longer **P** could be indicative of the fact that the internal clock is "producing pulses at a considerably decreased rate" (Binkofski & Block, 1996, p. 491), it is more likely that "when humans are required to produce an integer number of seconds they count up to that integer value" (Wearden, 1991, p. 71). If chronometric counting is involved, the multiplicative model for produced duration (Glicksohn, 2001) holds, **P** being the product of the number of subjective time units (n) and the size of the subjective time unit (S): $\mathbf{P} = nS$, which, after log transformation, gives $\log(\mathbf{P}) = \log(n) + \log(S)$; hence mean $\log(\mathbf{P})$ = mean $\log(n)$ + mean $\log(S)$. While this is a simple linear and additive function of the number of required counts (Killeen, 1992), it is nevertheless convenient to employ the log transformation so that we can work with the same data on the same scale, with these two models in mind. Specifically, as we shall subsequently show, mean log(**P**) is the key measure here.

To count or not to count? That is the question

Some researchers argue that chronometric counting should be discouraged (Kladopoulos, Hemmes, & Brown, 2004; Mimura, Kinsbourne, & O'Connor, 2000); however, others argue that counting should be encouraged (Miró, Cano, Espinosa-Fernández, & Buela-Casal, 2003; Myers & Tilley, 2003). Chronometric counting is believed to improve performance (Hinton, Harrington, Binder, Durgerian, & Rao, 2004; Ryan, Henry, Robey, & Edwards, 2004), either by reducing intraindividual variance for **P** (Wearden, 1991), or by making this variance independent of **T** (Grondin, Ouellet, & Roussel, 2004). But, a closer look is warranted here.

Chronometric counting was once viewed with disdain, because according to some authors, counting "does not truly reflect the perception of duration per se" (A. D. Eisler & Eisler, 1994, p. 186). Counting produced data violating the scalar property of the psychophysical function relating perceived (here, produced) time to target time, namely "proportionality between the standard deviation of a response distribution and the duration being timed" (Hinton & Rao, 2004, p. 24). As Allman, Teki, Griffiths, and Meck (2014) have advised, when one tries to identify those individuals who employ counting, rather than bona fide timing, in a psychophysical study, "If participants are counting rather than timing, and count at similar rates for all durations, their count totals will be proportional to the durations that they are instructed to time. In this case, the standard deviations of their counting distributions will be proportional to the square root of the duration rather than to the target duration itself as required for scalar timing." Counting, in turn, is (or, was) viewed as being beneficial (e.g., Gaudreault & Fortin, 2013; Grondin, Meilleur-Wells, & Lachance, 1999), both in terms of accuracy (more accurate) and in terms of variability (less variable)—all relative to what one would expect from the scalar property. Hence, when task performance is suspect of chronometric counting, one can "systematically test whether the scalar property of variance still holds. This investigation could eventually also be done individual per individual in order to exclude from the final sample the few number of participants that have not respected the instructions" (Rattat & Droit-Volet, 2012, pp. 78–79). There are, however, two major problems with this strategy. First, counting is not necessarily advantageous (Thönes & Hecht, 2017). Second, common methods used to prevent counting in a study might solve one problem (i.e., counting), but then introduce

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a more serious problem in the data, such as the possibility that "the instruction to not count may itself engage executive inhibitory processes" (S. W. Brown et al., 2013, p. 951), and/or that in preventing counting, "psychologists are not dealing with the best performances of their participants" (Grondin et al., 1999, p. 994).

In this paper, we exploit the fact that a number of participants who had previously participated in a study wherein TP was assessed (Berkovich-Ohana et al., 2012), and who had employed chronometric counting then, would be coming back to the lab to participate in a second study (Berkovich-Ohana, Dor-Ziderman, Glicksohn, & Goldstein, 2013). In the Berkovich-Ohana et al. (2013) paper, our focus was on the underlying neural activity accompanying alterations in the sense of time and space, related to alterations in bodily processing. The participants were asked to volitionally bring about distinct states of "timelessness" (outside time) and "spacelessness" (outside space) while their brain activity was recorded by magnetoencephalography (MEG). The TP data collected in that study (and not reported on previously) are the focus of the present paper.

Chronometric counting instantiates Treisman's (1963) internal clock: "The movement of the vocal apparatus, with its resonant frequency around 4 Hz, constitutes the pacemaker; the number system constitutes the register; the initiation of counting in response to the interval onset constitutes gating; the matching of the counts registered with a target constitutes the comparison" (Bizo, Chu, Sanabria, & Killeen, 2006, p. 201). We specifically requested that the meditators should not employ chronometric counting this time, thus allowing us to contrast TP with and without counting. As one reviewer has suggested, however, given that the counting condition always preceded the non-counting condition, the first will invariably impact on the second, and we cannot control for this. We therefore present two considerations that preclude this conclusion. First, Bartholomew, Meck, and Cirulli (2015) recently reported a study on TP, wherein both counting and non-counting conditions were employed. In their study (as in ours), "[t]ask type (*counting* vs *timing*) was not counterbalanced," and this was, as they write, because "performance was previously shown to be unaffected based on task order" (p. 5). Second, approximately 18 months had passed between the two sessions in the lab, hence any impact in our study seems quite unlikely.

In line with a recent study (Glicksohn & Leshem, 2011), we investigate how counting or not counting influences TP. We suggest that while participants can be prevented from counting (Rattat & Droit-Volet, 2012), what they actually do when not counting is *terra incognita.* Our experienced meditators had all employed chronometric counting in their first session with us (Berkovich-Ohana et al., 2012)—which is perfectly natural. What strategies would they adopt when not counting? How would these strategies affect their TP performance? How would these be related to their temporal experience? The present report will be engaged with these issues.

Method

Participants and design

Participants were 12 (10 males and two females, M_{age} = 45.2 years, *SD* = 11.3 years, age range: 31–66 years) of the 36 Mindfulness Meditation practitioners who had participated in our electroencephalography (EEG) study of meditation (Berkovich-Ohana et al., 2012), and who had returned to participate in our MEG study of meditation (Berkovich-Ohana et al., 2013). All were right-handed, healthy, very experienced meditators with an average of 16.5 (*SD* = 7.9, range: 9–34) years of meditation practice, and an average of 11,225 (*SD* = 9909, range: 1,290–29,293) total hours of meditation practice. In each study, we recorded an eyes-closed baseline task of TP. The study was approved by the Research Ethics Board of Bar-Ilan University; participants gave their written informed consent.

Time production

Four target durations of 4, 8, 16, and 32 s served for the TP task. The participants were required to remain with eyes closed while producing each of these target durations, pressing a finger button when they estimated that the time that passed from a "beep" sound equaled the target duration. Each target interval was produced twice, the target durations being presented in two series, each having a random order of the four target durations. The participants were subsequently requested to report on the strategy they adopted in performing the task. **P** and **T** durations were both log-transformed (to base 2), rendering thereby a linear scale for both ranging for **T** between 2 and 5, with a mid-point value of 3.5. Log(**P**) was then regressed on log(**T**), providing for each participant an intercept value, and a slope value (see Table 1), where the slope is equivalent to

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the exponent of the power function relating **P** to **T**. Hence, when the slope differs markedly from 1, **P** is not a linear function of **T**.

All our participants reported employing chronometric counting of one form or another (e.g., breath counting, counting "21," "22," etc.) in the EEG study. When they had returned for the MEG study, they were explicitly instructed not to count.

Results

TP data

For one individual (D.T.), an outlier for the 16-s target duration was observed, and this data point was deleted. Other than this, the participants exhibited monotonicity in their data (i.e., **P** for 4 s should be less than that for 8 s, which in turn should be less than that for 16 s). Inspection of the individual psychophysical functions confirms linearity for 11 participants (see Table 1), r^2 values ranging between 0.918 and 0.996 (one participant, R.O., was dropped from this particular analysis of the TP data due to the low r^2 value for one condition).

In comparing these participants, one option is to look at the estimates for α (intercept) and β (slope)—presented in Table 1. The slope values range between 0.928 and 1.063 when counting (for outlying participant R.O., this is 0.797), and all are significantly different from zero at the 0.05 level (and usually at the 0.0001 level); when not counting, these values range between 0.684 and 1.032, and again all are significantly different from zero. Any ensuing analysis of these data must assume linearity in the log–log plot, in order to pool across participants within each condition. We note, however, that our participants present two major forms of interaction, when the log–log plot given counting is juxtaposed with that given no counting. Figure 1 exemplifies these two forms of interaction.

One group, labeled here as *A*, comprises four participants (D.T., O.A., Y.D., A.T.) and is exemplified by the data for A.T. (Figure 1A), and here the log–log plot given counting is, indeed, linear, and tends to portray *shorter* produced duration than that obtained given no counting, especially for the shorter target intervals. When not counting, however, the log–log plot for these participants tends both to be nonlinear, and also to exhibit longer produced duration at shorter target durations, and shorter produced durations at longer target durations.

The other group (*B*) of eight participants (S.F., T.P., M.K., N.A., R.O., E.L., L.G., and A.P.), here exemplified by the data of A.P. (Figure 1B), again exhibits linearity when counting, with *longer* produced duration than that obtained when not counting, which is also usually linear (A.P., L.G., E.L., N.A., M.K., and T.P.), but sometimes is not (R.O., as noted earlier, and S.F.). Hence, when our participants are allowed to count, their log–log plot is linear, as one would expect. When not counting, between-participant variability in the nature of the log–log plot is quite high.

Given this situation, we focused on the four individual mean log(**P**) values, and investigated the Condition × Duration (4, 8, 16, 32 s) interaction, by running an analysis of variance (ANOVA) with repeated measures (Glicksohn & Hadad, 2012). This significant interaction, $F(3, 30) = 10.80$, $MSE = 0.025$ $p < .005$, indicates, as clearly seen in Figure 2, that the difference between counting and not counting is more clearly revealed at longer

Table 1
*Individual Mean Log(**P**), Intercept and Slope Values for Time Production (TP), When Counting and When Not Counting*

Participant	Sex	Mean log(**P**)		Intercept		Slope	
		Counting	Not counting	Counting	Not counting	Counting	Not counting
A.T.	Male	3.69	3.73	−0.033	0.837	1.063	0.828
A.P.	Male	4.17	3.70	0.807	1.296	0.959	0.688
M.K.	Male	3.72	3.27	0.145	0.395	1.020	0.821
D.T.	Female	3.37	3.83	−0.075	0.216	1.021	1.032
Y.D.	Male	4.20	4.26	0.528	1.538	1.048	0.778
T.P.	Male	3.53	3.13	0.026	0.033	1.002	0.884
L.G.	Female	3.86	2.90	0.432	−0.423	0.978	0.948
O.A.	Male	3.12	3.52	−0.348	0.843	0.991	0.764
E.L.	Male	3.81	3.44	0.242	0.164	1.018	0.937
S.F.	Male	4.04	3.35	0.791	0.459	0.928	0.826
R.O.	Female	4.67	3.57	1.876	0.452	0.797	0.890
N.A.	Male	3.82	3.45	0.378	1.054	0.983	0.684

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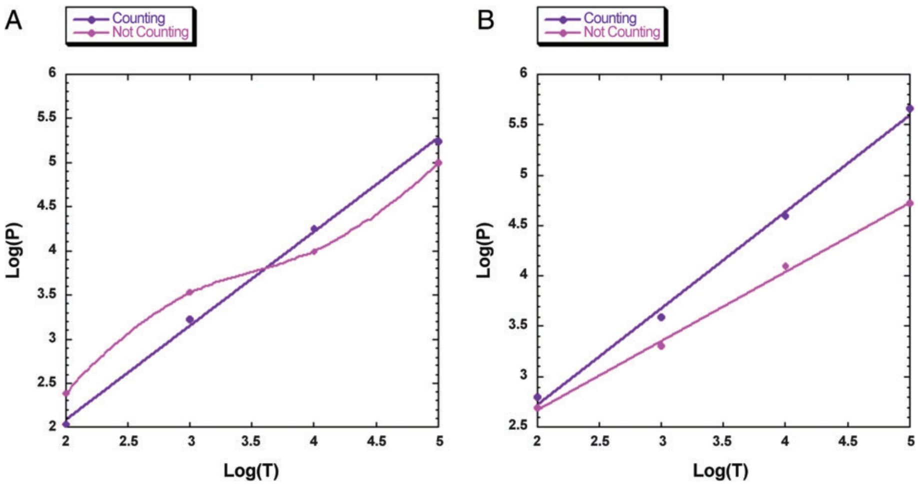

Figure 1. Mean log(**P**) as a function of log (**T**), presented separately for participant A.T., exemplifying Group A, and for participant A.P., exemplifying Group B.

target durations, with produced duration given counting being longer than produced duration given no counting. Given our previous inspection of the individual log–log plots, we refine this conclusion by noting that this is the case only for Group *B*.

Computing mean log(**P**) per participant, we can report the following: (1) Given two values for each duration produced, the test–retest correlation within session is .84 ($p < .005$), when counting, and .78 ($p < .005$), when not counting; this compares favorably with a within-session, test–retest correlation of .83, using the same task, that we reported for a sample of 77 participants who employed chronometric counting (Glicksohn, Berkovich-Ohana, Balaban Dotan, Goldstein, & Donchin, 2009). (2) When counting, there is a slight increase in mean log(**P**) within session (difference score [dif] = 0.09, $t = 2.77$, $p = .0197$); and when not counting, this increase (dif = 0.14, $t = 1.72$, $p = .1160$) is not significant.

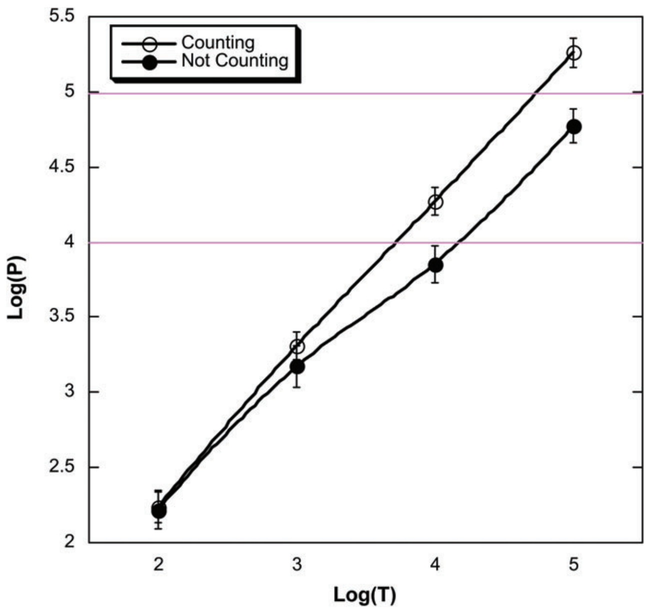

Figure 2. Mean log(**P**) as a function of log(**T**). Values reported are $M \pm SEM$.

Subjective experience of time: Strategy and content

The challenge of performing the TP task while not counting was handled by our meditators by means of two major strategies (see Table 2): (1) by relying on sensation, including the sensing of bodily presence (A.T., D.T., M.K., Y.D., S.F., T.P., and E.L.); and (2) by imaging an analog clock, an internal clock, or a visual timeline (A.P., N.A., L.G., O.A., and R.O.). There is some degree of overlap between the first group and the Group A participants noted earlier (A.T., D.T., and Y.D.) who exhibit nonlinearity in the log–log plot of their TP performance when not counting. There is also some degree of overlap between the second group and the Group B participants, noted earlier (A.P., L.G., R.O., and N.A.). Our five mismatches (M.K., S.F., T.P., O.A., and E.L.) reported such strategies as changing midway from initial counting to relying on sensation (M.K.), or changing midway from visualization to intuition (S.F.).

Discussion

Rakitin et al. (1998) suggested that future research "would be required to establish definitively a qualitative difference between chronometric counting and timing without counting" (p. 28). The present research has done just that: When participants are allowed to count, their **P** tends to be a

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Table 2
First-Person Reports of Time Production Strategy[a]

Participant	EEG study	MEG study
D.T.	Verbal/auditory and breath counting	An intuitive sensation, it was unclear—the length of the time, I just felt I needed to press the button.
O.A.	Verbal/auditory counting	I was guessing by sensation. Maybe I took my pulse as a possible reference; sometimes I paid attention to my heart rate and thought how much time passed. I also thought that 32 is twice 16, which is twice 8.
Y.D.	Verbal/auditory counting	It was very challenging, because I tried not to use any strategy and only count on sensation, but there was no point of reference. It was intuition, trying to mentally estimate or recall how much time passed.
A.T.	Verbal/auditory counting	I estimated. I checked with myself—is it time yet? There was a sensation of my breath and presence, but I tried not to count on that.
S.F.	Verbal/auditory counting	Intuitively. At the beginning there was one time I imagined visually a clock. The other times there was just a feeling of knowing.
A.P.	Verbal/auditory counting	I imagined an analog clock.
L.G.	Sensory counting	In the shortest interval (4) I couldn't help counting, it was inevitable. In the longer intervals, I saw something, it was visual, like a chewing-gum stretching. I tried to imagine how long was the line.
N.A.	Verbal/auditory counting	Not by counting but by time estimation. The moment it seemed to me that the time passed, I pressed the button. As if an internal clock told me "now," but it was abstract, without internal verbalization or visions.
T.P.	Verbal/auditory counting	I tried forcefully not to count, I just estimated a little by the breath/ they gave me some indication of the passing time, but it wasn't precise. There was internal verbalization involved in the process, debating "is it time already?"
M.K.	Visual counting	At the beginning there was a tendency to count, but I let go of that, then there was a sensation, then an image, and then I let go of all of that and I felt I was floating in space and guessing. Especially in the long intervals.
R.O.	Sensory counting (using the breath)	It was like seeing a shadow in a circle, like a sun clock, it was visual, but then the breath entered, and it became sensory-spatial.
E.L.	Both auditory and visual counting	In the short intervals, there was a moment that a sensation arrived—it's time to press. In the long intervals there was a sensation localized in my head that increased and increased towards the pressing. My awareness just knew when to press.

Note. EEG = electroencephalography; MEG = magnetoencephalography.
[a] For the EEG experiment, participants were given a choice between *verbal/auditory counting/sensory counting/visual counting/something else.* For the MEG experiment, participants freely answered the question: "How did you estimate the time?"

linear function of **T** (slope approaching the value of 1, when both are log-transformed); (2) when instructed not to count, they exhibit a shorter mean log(**P**) value at shorter target intervals than when allowed to count. Furthermore, we find our participants to be systematically *less* veridical when counting, M of mean log(**P**) = 3.83, than when not counting (M = 3.51, which coincides with the expected midpoint value of 3.5). As Thönes and Hecht (2017) have recently shown, counting does not necessarily improve the *accuracy* of TP.

This is the same pattern of results as that recently reported with respect to the task of reproduction (Glicksohn & Leshem, 2011). In that study, we employed the same target durations as here, with the addition of one of 2 s, and computed a similar log transformation of both reproduced duration (**R**) and **T** (rendering an expected midpoint value of 3). One group of participants, who were instructed to count, exhibited a mean log(**R**) of 3.39; a second group of participants, who were instructed not to count, were more veridical (M = 3.14). Requesting our participants not to count was surely effective (Rattat & Droit-Volet, 2012). But, this did not result in a more veridical mode of time estimation: When not counting, the data are clearly nonlinear, and when counting the data are clearly not veridical.

When not counting, between-participant variability is quite high, as seen both in the TP data and in the reported strategy. The natural strategy for mindfulness meditators to adopt, both in order to sustain mindfulness and in order to perform the TP task, would surely be that of breath counting (Levinson, Stoll, Kindy, Merry, & Davidson, 2014). When prevented from counting breaths, they would then resort to other bodily signs, for as Wittmann (2015) suggests, " 'attention to time' in essence means 'attention to bodily signals' " (p. 174), though whether this would really be helpful in the TP task is debatable (Otten et al., 2015). The advantage of employing a sample of proficient meditators lies in their ability to be mindful of their experience

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while not engaged in chronometric counting. The limitation of this study is that we have no control group of participants who are not proficient in mindfulness meditation. Hence, we cannot know whether these reported strategies are meditation-specific. This is worthy of further study.

A second limitation of the present report is that the counting condition (Berkovich-Ohana et al., 2012) preceded the no-counting condition (Berkovich-Ohana et al., 2013) for all participants. We are less concerned with such an order effect than with the fact that we observe marked individual differences in TP when participants are asked not to count. This leads us to consider a third limitation of the study, namely that no feedback was provided to aid our meditators to better calibrate their produced duration to the target duration. How such feedback might impact the strategy adopted is yet another area that requires research attention.

We have stumbled on an interesting finding, seen in the data of a number of our meditators when not counting, and this pertains to the discontinuity of the function (see Figure 1A) sometime between 8 s and 16 s. We have recently observed a similar phenomenon, using this TP task, with another group of meditators, who were exposed to whole body perceptual deprivation (Glicksohn, Berkovich-Ohana, Mauro, & Ben-Soussan, 2017). What we proposed there was as follows: “An intriguing possibility is suggested by these data: Linearity for the first two data points, and linearity for the last two data points, with discontinuity of the function between these regions” (p. 6). We also made reference to the relevant literature. Let us amplify on this: A point made consistently by H. Eisler and A. D. Eisler in their papers on time reproduction was the appearance of a discontinuity or “break” in the psychophysical function for experienced duration. Thus, H. Eisler (2003) writes:

> Breaks in the psychophysical function for duration are the rule; in more than one hundred data sets we have found very few without a break, and these also show so much agreement with physical (clock) time, as opposed to other data, that we suspect that these subjects counted, in spite of the instruction not to count. (p. 23)

In noting this difference between counting (no break) and not counting (break), H. Eisler is suggesting here that the appearance of such a break is diagnostic of the strategy adopted in performing the task. In fact, H. Eisler (1996) relays his “suspicion, though no clear evidence, that the subjects who produced these data were using some premeditated strategy, like counting” (pp. 72–73). In the present study, we can confirm that the break appears only when the meditators were not counting. What does this break reveal? H. Eisler and Eisler (1992) suggest that

> The break in the psychophysical function is an ubiquitous phenomenon in time perception and is not limited to duration reproduction experiments. … It may be interpreted as an automatic attempt to maximize accuracy for different portions of the time continuum, analogously to the change in the range of a voltmeter for different voltages. (p. 357)

The hunt is now on for finding these breaks in one’s data. As Bartholomew et al. (2015) have recently written, “[r]esearchers look for transitions or ‘break points’ where one timing mechanism stops operating and/or loses sensitivity and another takes over. This is indicated by sudden jumps in the sensitivity to time” (p. 2).

In the present context, we believe that a comment made by Pöppel (2004) is helpful: “It can … be demonstrated that in other temporal regions indifference points occur which … are created by the specific experimental conditions” (p. 297). Requesting meditators not to engage in chronometric counting, and thereby forcing them to rely instead on other cues (sensory, bodily, etc.), might well be an appropriate context (“specific experimental condition”) in which to observe such a discontinuity in TP. In spite of the clear limitation of the small sample reported here, and the exploratory nature of the results, given that there are only a few articles (Wearden, 2016, p. 272) on this interesting distinction concerning the use of chronometric counting (or not) in time perception, the present report makes a contribution both to that literature and to the theme of this special issue, on altered states of consciousness and time perception.

Disclosure of conflict of interest

The authors declare there are no conflicts of interest.

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