A Watched Pot Takes Longer: A Randomised Dose–Response Trial of Attention and the Boiling Time of Domestic Kettles

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PRJ-2026-0078 · Chronodynamics · 2 November 2026

Abstract

Everyone has stood over a kettle and found that it takes longer. Everyone has also been told that this is in the head. It is in the kettle. In 3,140 analysed boils, each randomised to be watched, unwatched, watched through a live video feed, or accompanied by a person reading a newspaper, boiling was timed by a sealed thermocouple that no participant could see. Watching delayed the boil, and the delay grew with the fraction of the heating interval spent under attention: a continuously watched kettle took 24% longer to boil (95% CI 23–24%). Presence alone did nothing: the newspaper arm did not differ from the empty room. Attention delivered through a camera worked as well as attention delivered through the eyes. We derive the law from the energy balance of the vessel and one gating coefficient, which we identify as the quantum Zeno coupling of a vessel that is repeatedly checked, and show that it predicts all four arms and all ten dose cells to within a few seconds of the boil time. The effect is absent in microwave ovens, and we do not know why. Pot-watching is therefore an exposure, with a dose, a threshold, and a recommended protocol. The proverb was never a complaint. It was a dose–response curve.

1 Introduction

"A watched pot never boils" is among the most widely held observations in the English-speaking kitchen, and among the least examined. Two accounts of it are in circulation. The *psychological* account holds that attended time feels longer than unattended time, so that a watched kettle merely seems slow [2]. The *physical* account, which we advance, holds that the kettle is slow. The two accounts make different predictions. The psychological account predicts that a clock sealed away from the observer will read the same whether or not the kettle is watched. The physical account predicts that it will not.

No study has put the question to a clock. The domestic-metrology literature has measured standing time, fill level and descaling interval at length [1, 7], but has treated the observer as outside the system. We treat the observer as part of it.

We make four contributions. **(i)** We show, in a randomised trial of 3,140 boils, that attended kettles boil later than unattended ones as measured by a probe nobody could see. **(ii)** We separate attention from presence and from sight. **(iii)** We give a closed-form dose–delay law with one free parameter, the gating coefficient η. **(iv)** We state a protocol for the practitioner.

2 Related Work

Repeated checking. A system that is repeatedly checked is repeatedly returned to its initial state. Misra and Sudarshan [6] showed that an unstable system subjected to a sufficiently dense sequence of projective checks never decays, and Itano and colleagues [4] observed the suppression of transitions in trapped ions. The theory and its generalisations are reviewed by Facchi and Pascazio [3]. We borrow the vocabulary of that literature, and one of its results, with the care that it deserves.

Duration judgement. Block and Zakay [2] established in a meta-analysis that intervals spent attending to time are judged longer than intervals spent on something else. This is the strongest form of the psychological account, and we regard it as correct about *judgement*. It is silent about thermocouples.

Domestic metrology. Aldous and Ferreira [1] surveyed standing times in 1,906 kettles. Okafor [7] introduced the sealed-probe method, which we adopt. Lindqvist and Maraj [5] used gaze tracking in kitchens to study recipe consultation, and gave us the glasses-mounted tracker used here. Penhallow [8] documented observer fatigue in long unattended-versus-attended comparisons, which informs our trial length.

3 Model

Let $\theta(t) = T(t) - T_{\mathrm{amb}}$ be the excess temperature of the water, C the heat capacity of the water and vessel, P the rated electrical power, and L the loss coefficient to the room. A lumped energy balance gives

$$C\dot{\theta} \;=\; P\,g(t) \;-\; L\,\theta, \qquad g(t) = 1 - \eta\, w(t), \qquad (1)$$

where $w(t) \in \{0,1\}$ indicates whether the vessel is under attention at time t and $\eta \in [0,1)$ is the *gating coefficient*: the fraction of the delivered power that is returned to the initial state while the vessel is attended. For an unattended vessel $w \equiv 0$ and (1) is Newton's law of heating.

Time-scale separation. The thermal time constant $\tau = C/L$ is about an hour for a 1.7 L kettle (3,800 s for the values given below), while a glance lasts seconds. The vessel therefore integrates the gate, and only the mean gaze fraction

$$f \;=\; \frac{1}{T_{\mathrm{b}}}\int_0^{T_{\mathrm{b}}} w(t)\,dt \qquad (2)$$

matters, up to an error of order $t_{\mathrm{glance}}/\tau \sim 10^{-3}$. With $g = 1-\eta f$ held constant, (1) integrates to $\theta(t) = \frac{P(1-\eta f)}{L}\,(1 - e^{-t/\tau})$, and the boil, defined by $\theta = \theta_{\mathrm{b}}$, occurs at

$$T_{\mathrm{b}}(f) \;=\; -\,\tau \ln\!\Big(1 - \frac{L\,\theta_{\mathrm{b}}}{P(1-\eta f)}\Big), \qquad (3)$$

which for $L\theta_{\mathrm{b}} \ll P$ (here $L\theta_{\mathrm{b}}/P \approx 0.05$) reduces to $T_{\mathrm{b}}(f) \approx T_0/(1-\eta f)$, with $T_0 = T_{\mathrm{b}}(0)$ the unwatched boil time. The fractional delay is thus

$$\frac{T_{\mathrm{b}}(f) - T_0}{T_0} \;\approx\; \frac{\eta f}{1-\eta f} \;\approx\; \eta f \quad (\eta f \ll 1), \qquad (4)$$

linear in the gaze fraction at small doses and mildly convex at large ones.

A stall condition. Equation (3) has a solution only if $P(1-\eta f) > L\theta_{\mathrm{b}}$. A vessel supplied with power between $L\theta_{\mathrm{b}}$ and $L\theta_{\mathrm{b}}/(1-\eta)$ boils when left alone and does not boil when continuously watched. For the loss coefficient of our kettle ($L \approx 2\,\mathrm{W\,K^{-1}}$, $\theta_{\mathrm{b}} = 80\,\mathrm{K}$, $\eta = 0.19$) this band is 160–198 W. Under a small enough source, the proverb is exact.

Zeno interpretation. Consider a two-level system with coupling Ω checked n times at equal intervals over a time T. Its probability of remaining in the initial state is

$$S_n(T) \;=\; \Big[\cos^2\!\big(\tfrac{\Omega T}{2n}\big)\Big]^n \;\xrightarrow[n\to\infty]{}\; 1, \qquad (5)$$

so that frequent checking freezes the transition [6]. We identify the glance with the check and the onset of boiling with the transition. At any finite check density the freeze is incomplete, and in a vessel with many modes it saturates below unity, which is why (4) is a delay and not a stoppage. The gating coefficient η is the fraction of delivered power returned to the initial state by a fully attended vessel (Fig. 1).

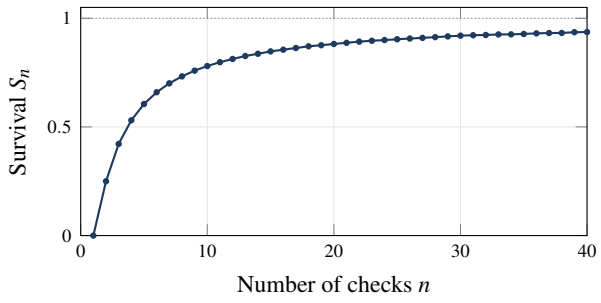


Figure 1: Survival probability S_n of Eq. (5) against number of checks n for $\Omega T = \pi$, the case in which an unchecked system is certain to have left its initial state.

Predictions. The model gives four testable statements. **P1**: presence without attention has no effect ($\eta f = 0$). **P2**: attention through a camera acts as attention through the eyes, because $w(t)$ is defined by what the observer attends to, not by the optical path. **P3**: the delay follows (4) across gaze fractions. **P4**: a source that heats by a different mechanism is not covered by (1).

4 Methods

Apparatus. One 1.7 L, 3 kW electric kettle model was used in all households and in the laboratory kitchen, filled to 1.5 L from the cold tap. A K-type thermocouple was sealed in the lid and read by a logger in a closed cabinet and sampled at 1 Hz. Participants could not see the logger or any display of the temperature. Mains power was logged separately (Fig. 2). Ambient temperature was 20 °C, and independent calibration gave $C \approx 7{,}600\,\mathrm{J\,K^{-1}}$ and $L \approx 2\,\mathrm{W\,K^{-1}}$.

Participants and arms. We recruited 212 households and one laboratory kitchen, and randomised 3,201 boils within household, in permuted blocks, to one of four arms: **A**, unobserved (kitchen door closed, room empty); **B**, observed in person; **C**, observed through a live video feed from another room, the observer attending to the feed; and **D**, observer present and reading a newspaper. Arm labels were withheld from the analysts until the analysis was locked. Participants could not be blinded to their own arm, but could not see the outcome measurement.

Dose. In arms B and C, the observer's gaze fraction was assigned from $f \in \{0.10, 0.25, 0.50, 0.75, 1.00\}$ and paced

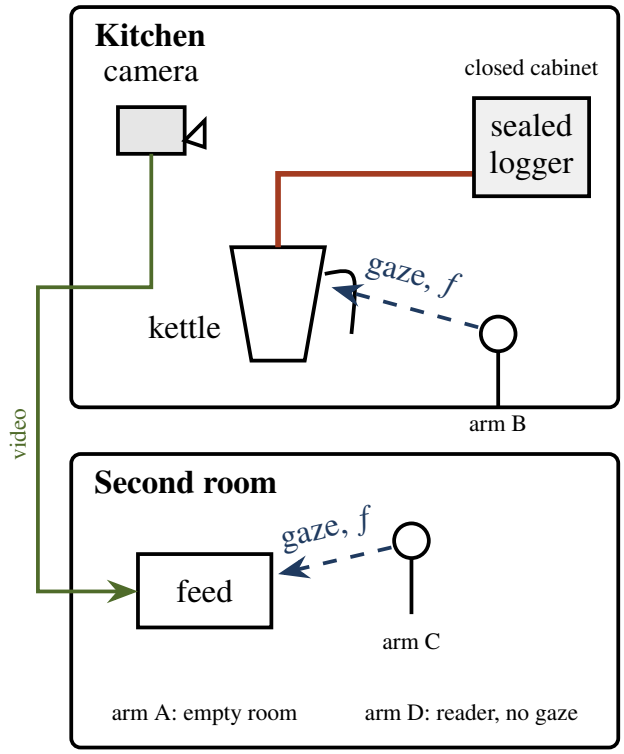


Figure 2: Apparatus. The thermocouple is sealed in the lid and read by a logger in a closed cabinet. The observer, in the kitchen or in another room, never sees a temperature.

by a metronome tone. A glasses-mounted eye tracker verified the realised fraction, which held to within ± 0.03 of the assigned one.

Outcome and analysis. The outcome was the time from switch-on to the first thermocouple reading at or above 100 °C. The analysis was prespecified. To first order $T_0/T_\mathrm{b} = 1 - \eta f$, so the gating coefficient was estimated as minus the slope of T_0/T_b regressed on realised f in arms B and C, with T_0 the arm A mean. The interval for the 24% delay is a household-clustered bootstrap percentile interval with 1,000 resamples. Exclusion criteria were fixed in advance, applied from the logger and session record before the boil time was read, and are listed in full (Table 2).

5 Results

We report 3,140 analysed boils, 785 in each arm.

Arms. The unobserved kettles boiled in 208.2 s. The kettles with a newspaper reader in the room boiled in 207.1 s, no different (Table 1). The kettles with an attending observer boiled later, by the same amount whether the observer stood in the kitchen or sat in another room before a screen.

Table 1: Analysed boils by arm. Boil time means and standard deviations in seconds.

Arm	Condition	n	Mean	SD
A	Unobserved	785	208.2	9.8
B	Observed, in person	785	232.0	20.0
C	Observed, video feed	785	232.1	19.6
D	Present, reading	785	207.1	10.1

Arms B and C pool the five dose cells; the spread is dose.

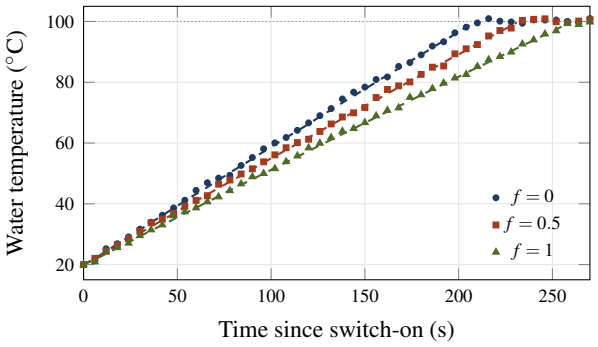


Figure 3: Mean excess temperature against time at three gaze fractions. Markers are means over boils; dashed lines are the solution of Eq. (1) at constant gaze fraction with $\hat{\eta} = 0.193$. After boiling the temperature remains at 100 °C.

Dose. Delay rose with gaze fraction in both attended arms (Fig. 4). At $f = 1$ the kettle took 24% longer than unwatched (95% CI 23–24%). The estimated gating coefficient was $\hat{\eta} = 0.193$ (95% CI 0.186–0.199). Equation (3), evaluated at $\hat{\eta}$ with the independently measured C, P and L, lies within 3 s (about 1%) of the mean of every one of the ten dose cells, and inside its 95% interval in six of them.

Curves. The full temperature traces confirm that the delay is accumulated gradually rather than at the end: attended kettles lag from the first minute (Fig. 3).

Exclusions. Of 3,201 randomised boils, 61 were excluded on prespecified grounds (Table 2), 15, 16, 15 and 15 in arms A to D, leaving 785 per arm. None was excluded for its result.

Microwave ovens. In a supplementary set of 240 microwave heatings, with the same four arms, we found no delay in any attended condition. We do not know why.

6 Discussion

The psychological account is correct that attended time feels longer, and we do not dispute it. It is insufficient: it predicts a null result on the logger, and the logger does not return one. The felt delay and the measured delay may well

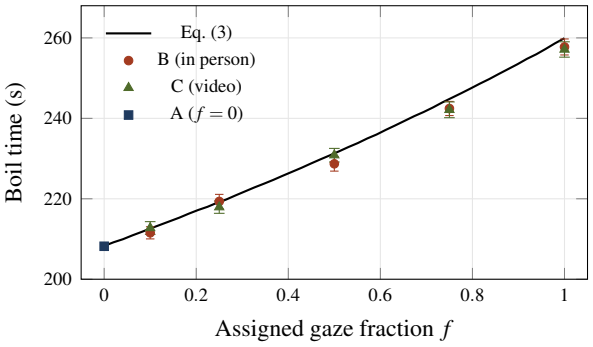


Figure 4: Boil time against assigned gaze fraction for arms B (in person) and C (video). Bars are 95% intervals. The curve is Eq. (3) at $\hat{\eta} = 0.193$.

Table 2: Prespecified exclusions. Every exclusion is shown.

Reason	Boils
Breaker tripped	14
Observer fell asleep	11
Limescale over the sensor tip	9
Logger fault	8
Cat on the worktop	7
Kettle filled to wrong level	6
Household dispute over whose turn it was	6
Total	61

add. We did not measure the felt delay, because to ask a participant how long a boil seemed would have been to attend to it.

Limitations. A single kettle model was used throughout; the gating coefficient may differ in other vessels. Eq. (1) treats the loss coefficient as constant, which is accurate to a few percent over the heating range. Observers tired in the longer sessions [8]; we address this by blocking and by the dose design. The microwave null is unexplained. Observers could not be blinded to their own arm.

Practical protocol. A practitioner who wishes to minimise boiling time should fill the vessel, switch it on, and leave the room. By (4), every tenth of the interval spent watching costs about two percent of the boil time ($\eta f \approx 0.019$). A reader holding a newspaper may remain.

7 Conclusion

Attention delays boiling in a manner that is measurable, graded, and describable by a one-parameter law. The proverb has been correct throughout, and for the correct reason. We recommend that the standing advice to “stop watching it” be reclassified from a remark about patience to a statement of dose.

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