TEMPUS NON FUGIT? EFFECTS OF DEPRESSION, ATTENTION AND MEMORY ON TIME PERCEPTION

Diana E. Kornbrot, Rachel M. Msetfi, Robin A. Murphy,
University of Hertfordshire, Lancaster University, University of Oxford
d.e.kornbrot@herts.ac.uk, r.msetfi@lancaster.ac.uk, robin.murphy@psy.ox.ac.uk

Abstract

There is consistent evidence that depressive state affects time perception, although the relevant mechanisms are unclear. We used three paradigms to investigate such effects. The first uses production and verbal estimation of time in seconds, controversial in other studies. There were no significant depression effects for psychophysical functions. The second uses operant learning, an innovation for humans. Depressed participants gave longer estimates than non depressed participants for intervals preceding a change in external contingencies. The third uses a modified staircase to find 75% discrimination thresholds for shorter (50ms) and longer (1000ms) intervals. Depressed people have worse discrimination for longer intervals only. These results suggest that neither long term memory for times in seconds nor internal clock speed are implicated in mood effects in time perception. Mood differences are more likely to be due to attention paid to external stimuli and contexts

Depression has long been associated with disturbances in the experience of the passage of time. More specifically, when people are depressed, they often report that they feel time to be passing more slowly than usual. This finding has been linked to symptoms of depression, such as psychomotor retardation (e.g., Blewett, 1992), and could perhaps be linked to other time dependent disturbances in depressed people's cognitions, such as the perception of causality and helplessness, e.g. (Msetfi, Murphy, Simpson, & Kornbrot, 2005). However, while the evidence for depression related changes in subjective time experience is relatively strong, the picture is different when it comes to objective time judgement. This refers to the "objectively measurable capacity of a subject to judge the length of a given time span" (Bschor et al., 2004, p. 223) and evidence for this kind of temporal distortion in depression has been considered to be inconsistent and contradictory (e.g., Hawkins, French, Crawford, & Enzle, 1988). However, this inconsistency may be due to the widely varying procedures and experimental controls present in published studies (see Bschor, et al., 2004 for a discussion). For a comprehensive review of relevant models of time perception see (Grondin, 2010), also (Allan, 1998; Zakay, Block, MarÌa, & Julio, 1996)for more specific model details

The first aim of this study is to describe any differences in objective time judgement related to depression for time intervals of different duration. The second aim is to explore the cognitive mechanisms that underlie any such differences. Three possible mechanisms are considered: differences in the tick rate of internal clock[s]; differences in attention; and differential memory for intervals with well established labels in seconds.

Three experimental paradigms are used: estimation of labelled times; operant condition learning (previously only used with animals); and discrimination.

Methods

All three paradigms compared mildly depressed (MD) students (Beck Depression Inventory, BDI > 9) with non depressed (ND) students (BDI ≤ 8).

Experiment 1: Production and Verbal Estimation of Labelled Times

There were 24 mildly depressed and 28 non depressed students, with groups matched for intelligence and sex. All participants made verbal and production estimates of 6 time intervals ((3, 5, 15, 25, 40, 60 s). Participants were asked explicitly not to count or tap to aid their estimation of the durations. They were also shown a three-digit sequence written on a sheet of paper. They were required to hold this number in memory until the end of the experiment. Durations were randomised within conditions.

Experiment 2: Operant Conditioning Learning

In this paradigm, a positively reinforced response was switched between left and right after clock duration of 25 s. Participants had to learn the *time* when they should switch their response. The hypothesis was that depressed participants would be slower to switch their response. There were 24 non depressed and 24 mildly depressed participants.

The experimental task (presented on a desktop Mac) was to maximise the occurrence of a brief light flash, shown as a lamp bulb graphic in the centre of the screen, by pressing two on-screen buttons. The button on the lower left was activated with the 'tab' key that on the lower right with the 'return' key. The task was presented as one of problem-solving i.e. learning how to maximise the occurrence of the light flash. No mention was made of timing. Each trial was 50s long and separated by a 10s inter-trial interval. During the first 25s of each trial, presses of the "early" button were reinforced with a light flash at a probability of .85, while presses of the "late" button were reinforced at a probability of .15. Assignment of buttons to "early" or "late" was counterbalanced. The reinforcement probabilities were switched after 25s, so that the early button was reinforced at .15 and the late button at .85. There were 18 trials, of which 14 were training trials. The other 4 trials were interspersed among the training trials (trial numbers: 9, 12, 15 & 18) and were non-reinforced probe trials. Participants were told that there would be some trials (probe) where the light would not be shown, but that they should use what they had already learned in order to make the light flash as many times as possible. An onscreen message at the end of each trial (both reinforced and probe) reported the number of times the light had flashed during the trial. The proportion of key presses to the "early" button for each of the ten 5 s intervals within a trial was recorded.

Experiment 3: Discrimination Thresholds

The paradigm was two alternative forced choice discrimination, combined with a modified method of limits. There were two conditions: long, with a standard interval of 1000 ms; and short, with a standard interval of 50 ms, (Rammsayer, Hennig, Haag, & Lange, 2001).

Each condition comprised 32 trials. In the long condition, the initial comparison interval was 1400 ms. For trials 2 to 4, the comparison was reduced by 100 ms after each correct response and increased by 300 ms after each error. For trials 5 to 32, there was a decrease of 25 msec after each correct, and an increase of 75 msec after each error. In the short condition, the initial comparison was 75 ms. On trials 2 to 4, the decrease after correct was 3 ms and the increase after error was 9 ms; while for trials 5-32, decrease after correct was 2 ms and increase after error was 6 ms. Each trial was initiated by the participant pressing a start button which was followed by a 900 ms interval then the first interval demarked both visually and auditorially followed by a 900 ms intertrial interval of silence followed by the second visually and auditorially demarked interval, followed by a screen request asking participants to indicate which stimulus was on the screen for the longer period.

The procedure produces a series of 'runs' of successive correct and incorrect responses. Discrimination performance is measured by calculating a mean time discrimination threshold, using the mid-run estimates of the last 20 trials, for each participant (Rammsayer, et al., 2001). This measure, denoted here ‘discrimination75’, is used as the dependent variable in all the discrimination analyses. It has been shown to be a reliable of estimate of the difference duration at which participants are 75% correct (Wetherill, Chen, & Vasudeva, 1966). The mid point of the last run was only included in a participant’s average, if it was an unbiased end to the run, rather than a run artificially terminated by the end of the procedure.

The experiment was performed twice. In the first replication, experiment 3A, there were different groups of participants for the long and short interval conditions, 18 non depressed and 18 mildly depressed. In the second replication, experiment 3B, there were 79 right handed participants, all of whom performed in both conditions, counterbalanced for order.

Results

Experiment 1: Production and Verbal Estimation of Labelled Times

Power law exponents were obtained for each participant by regressing log(estimate) on log(duration) separately for verbal & production data. Fig. 1 shows group function obtained by regressing average log(estimate) on log(duration). Data from 6 participants with regression r-squared < .9 were not included in group analyses.

For verbal estimation: slope = .92 (.88, .96), min = .57, max = 1.20; intercept = +.36 (.22, .49). For production estimation: slope = .99 (.97, 1.02), min = .69, max =1.27; intercept = -.13 (-.28, .02). ANOVAs were performed separately on the individual slopes and intercepts, with mood (non depressed, mildly depressed) as a between participant factor and estimation method (production, verbal) as a within participant factor. There were main effects of estimation method for both slope, $F(1,43) = 4.8$, $p=.034$, effect size, Cohen□s□D = .39; and intercept $F(1,43) = 17.4$, $p < .0005$, Cohen□s□D = .80. Neither exponent nor intercept gave significant effects for mood, or mood by estimation method, with $F < 1$. The exponents are almost identical to those obtained by (Glicksohn, Ohana, Dotan, Goldstein, & Donchin, 2009), who instructed their participants to count. By contrast, their participants had mean intercepts close to zero, whereas ours had the usual overestimate for verbal, and underestimate for production, pattern. Hence counting seems to influence intercept only.

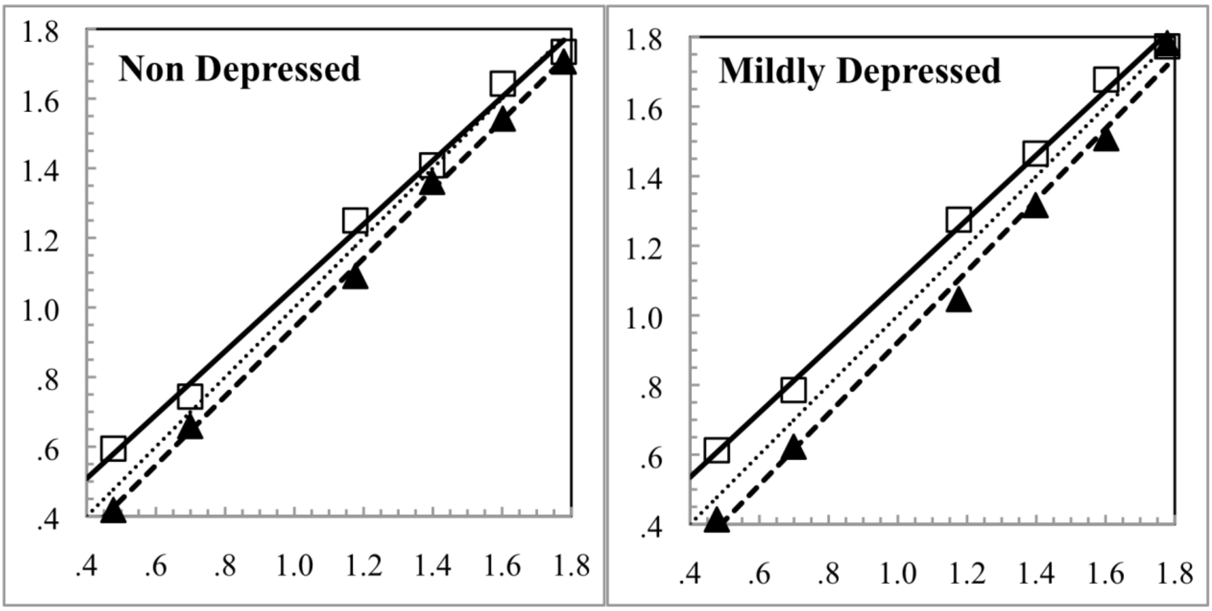

Figure 1. Log(time estimate) as a function of log(duration, sec). Open squares verbal estimation, filled triangles production estimation.

The slope and intercept differences in Fig. 1 are highly reliable, with results for non-depressed (left) not statistically significantly different from those for mildly depressed (right). There was an even higher than usual negative correlation between slope and intercept for both verbal (r = -.77) and production (r = -.77) estimation. The absence of an effect of depression seems to rule out clock speed and suggests alternative mechanisms leading to Expts. 2 and 3.

Experiment 2: Operant Conditioning

Only 30 out of 48 participants (17 non-depressed and 13 mildly depressed) learned to make the majority of their responses on the 'early' button during the first 25 seconds and on the 'late' button during the second 25 seconds of each probe trial. The other 18 participants tended to 'switch' back and forth between responses during probe, but not training. There was no relationship between being a 'switcher' and mood group, $\chi^2(1) = 1.42$, $p = .26$. Data from switchers were excluded from further analysis. Data from the final probe trial were used to estimate the difference between groups in participants' choice of time to switch response.

The 50% threshold for switching, T50, was obtained for each participant by interpolating between the T25 and T75 time. Fig. 2 shows the cumulative probability of pressing the late button as a function of time on the final probe trial for the 30 participants who learned the task. The interpolated values for T50 showed that all participants reached the indifference point later than 25s, but that the depressed participants reached the indifference point around 3s later (M = 30.45s, SE = 1.4s) than the non-depressed participants (M = 27.1s, SE = .7s). This difference in T50 was reliable, $t(28) = 2.11$, p=.04).

A key difference between the VE and PE tasks used in Experiment 1, which showed no effect of depression, and the free-operant task in Experiment 2, which gave a depression effect that *might* be interpreted as a slowed clock, is that the estimation task requires a stored memory of verbally labelled times. Conversely, in the operant learning task the 25s time is learned in the experimental session. The different effects of mood in experiments 1 and 2 led to a further investigation using a discrimination paradigm, which like experiment 1 required no memory of labelled times.

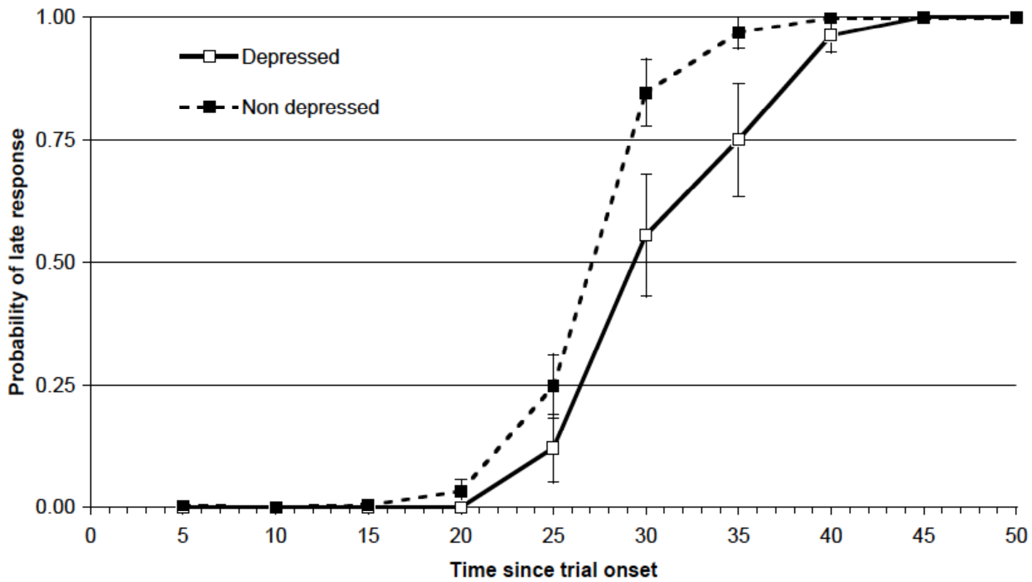

Figure 2. Probability of pressing the late button as a function of time since trial onset and mood. Error bars correspond to the standard error of the mean.

Experiment 3: Discrimination Thresholds

ANOVA on discrimiantion75 was performed separately for replications 3A and 3B. Planned comparisons for the effect of mood were conducted separately for the long and short intervals. In replication 3A, both mood and interval length (25ms, 1000ms) were between participant factors. In replication B, interval length was a repeated participant factor. Mood comparisons ANOVAs were also conducted for the combined 3A and 3b replication groups, separately for the long and short intervals, so as to increase power. Only right handers were included in the analyses.

All three mood comparisons (3A, 3B and combined) showed no significant effect of mood for the short time interval, with all Fs < 1, and overall mean discrimination75 =30s The power to detect a medium effect size (Cohen's D = .5) was .85 for the combined group. The ,long interval showed a different pattern. In experiment 3B the effect of mood was not significant even for the long interval, F(1,77) = 1.45, p =.232, D = .19. By contrast experiment 3A, the effect of mood was reliable, mean discriminatio75 = 163s for depressed and 107s for non-depressed participants, F(1, 34) = 5.6, p =.023, D = .57. The mood effect was also significant for the combined group, with mean discriminatio75 = 159 for depressed and 121s for non-depressed participants, F(1, 11) = 6.2, p =.014, D = .34.

Discussion

These results clearly show that there is an effect of even relatively mild depression on some, but not all, objective time estimation tasks. These differences merit theoretical consideration.

Experiment 1 shows no statistically reliable effects for psychophysical functions for remembered time, in seconds using either production or verbal estimation. The results for both depressed and non depressed are similar to classic magnitude estimation findings (Eisler, 1976) and more recent work (Glicksohn, et al., 2009). Hence we found no support for models of depression effects that depend on clock speed.

The operant learning paradigm of Experiment 2, new to human time perception research, generated a strong effect of mood with a difference of 3s in an interval of 25s corresponding to a 12% increase for the mildly depressed relative to the non depressed, which is sizable. These durations are similar to those used in typical experiments on the passage of time., and so are consistent with studies that show slower passage of time in the depressed.

Experiment 3 shows that discrimination of 'long' intervals of 1s is less accurate for depressed individuals. Again the effects are sizable, with an increase in 75% discrimination threshold for the mildly depressed from 110 ms to 140 ms for experiments 3A and 3B combined. By contrast, experiment 3 produced no significant mood effects for discrimination of very short intervals of 50 ms. It has been suggested that accuracy of discrimination depends on the speed of an internal clock. This is because more ticks per unit interval allows for finer discrimination. Thus is there is 1 tick per ms, then the difference between 50 ms and 75 ms is 25 ticks, but if there the rate is only 40 ticks/50 ms, then the difference between 50 ms and 75 ms is only 20 ticks, and so will be harder to discriminate. Hence the lack of a mood effect at short durations also suggests no role for mood effects on an internal clock.

Time perception research has always been hampered by methodological difficulties. The present study shows that the operant learning paradigms is particularly promising. Reliable mood effects were obtained from 18 trials of duration approximately equal to the test duration + 1s intertrial interval. So an estimate for a 120s interval could be obtained in 1 hour.

Theoretically, the results suggest that attention mechanisms mediate mood effects in time perception, just as they do many other phenomena described in the literature. Nevertheless, the exact attention mechanism(s) are far from clear. Some models suggest that attention influences the way signals from internal clocks are processed. Other models find no role for an internal clock, but suggest that divided attention is some more direct mechanism. Psychophysical models of heaviness do not involve internal weighing machines, so why does time require clocks?

In summary our results give further support to models that locate mood in the attention paid to external stimuli (Msetfi, et al., 2005; Msetfi, Murphy, Simpson, & Kornbrot, 2008). Future research to elucidate the attention mechanisms needs to directly compare the effects with those on other psychophysical domains; should use a wider rang of time intervals; and should directly manipulate both attention and mood.

References

Allan, L. G. (1998). The influence of the scalar timing model on human timing research. *Behavioural Processes, 44*(2), 101-117. http://www.scopus.com/inward/record.url?eid=2-s2.0-0032458152&partnerID=40&md5=b962a11d97262b1db5fc794783b1f7b5I.

Blewett, A. E. (1992). Abnormal subjective time experience in depression. *British Journal of Psychiatry, 161*, 195-200.

Bschor, T., Ising, M., Bauer, M., Lewitzka, U., Skerstupeit, M., Maller Oerlinghausen, B. (2004). Time experience and time judgment in major depression, mania and healthy subjects. A controlled study of 93 subjects. *Acta Psychiatrica Scandinavica, 109*(3), 222-229.

Eisler, H. (1976). Experiments on subjective duration 1868-1975: A collection of power function exponents. . *Psychological Bulletin, 83*(6), 1154-1171.

Glicksohn, J., Ohana, A. B., Dotan, T. B., Goldstein, A., & Donchin, O. (2009). Time production and EEG alpha revisited. *NeuroQuantology, 7*(1), 138-151. http://www.scopus.com/inward/record.url?eid=2-s2.0-67649999472&partnerID=40&md5=90d2dbee5939beea364db779aba8ad0eI.

Grondin, S. (2010). Timing and time perception: A review of recent behavioral and neuroscience findings and theoretical directions. *Attention, Perception, & Psychophysics, 72*(3), 561-582. http://app.psychonomic-journals.org/content/72/3/561.abstractI.

Hawkins, W. L., French, L. C., Crawford, B. D., & Enzle, M. E. (1988). Depressed affect and time perception. *Journal of Abnormal Psychology, 97*(3), 275-280.

Msetfi, R. M., Murphy, R. A., Simpson, J., & Kornbrot, D. E. (2005). Depressive realism and outcome density bias in contingency judgments: The effect of the context and intertrial interval. [Article]. *Journal of Experimental Psychology-General, 134*(1), 10-22. http://dx.doi.org/10.1037/0096-3445.134.1.10 I.

Msetfi, R. M., Murphy, R. A., Simpson, J., & Kornbrot, D. E. (2008). Impaired context maintenance in mild to moderately depressed students. [Article]. *The Quarterly Journal of Experimental Psychology, 62*(4), 653-662. http://dx.doi.org/10.1080/17470210802486092I.

Rammsayer, T. H., Hennig, J., Haag, A., & Lange, N. (2001). Effects of noradrenergic activity on temporal information processing in humans. *The Quarterly Journal of Experimental Psychology, 54B*(3), 247-258.

Wetherill, G. B., Chen, H., & Vasudeva, R. B. (1966). Sequential estimation of quantal response curves: A new method of estimation. *Biometrika, 53*(3/4), 439-454.

Zakay, D., Block, R. A., MarÌa, A. P., & Julio, A. (1996). The role of attention in time estimation processes *Advances in Psychology* (Vol. Volume 115, pp. 143-164): North-Holland. http://dx.doi.org/10.1016/S0166-4115(96)80057-4I