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Contributors

Punch, A. Lisle.
Myers, Charles S. 1873-1946.
Wilkinson, Russell.
Brooke, R. StC.

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THE INFLUENCE OF ULTRA-VIOLET
RAYS ON INDUSTRIAL OUTPUT.

BY A. LISLE PUNCH, M.B., M.R.C.P. LOND.,
AND
RUSSELL WILKINSON, M.V.O., M.R.C.S. ENG.

With the collaboration of
R. STC. BROOKE, M.A.,
AND
C. S. MYERS, C.B.E., M.D., F.R.S.

DURING October, November, and December, 1925, an investigation was conducted into the influence of ultra-violet rays on the output of girls engaged in the manufacture of chocolates in the works of Messrs. J. Lyons and Co., Ltd., at Greenford, Middlesex. The treatment was applied by Dr. Lisle Punch and Dr. Russell Wilkinson. The data of output were obtained by Mr. R. StC. Brooke, psychologist to the firm. The general planning and supervision of the investigation and the preparation of most of the following report were the work of Dr. C. S. Myers, aided by a grant to the National Institute of Industrial Psychology from the Laura Spelman Rockefeller Memorial. The investigators are indebted to Mr. Julius Salmon, one of the directors of the firm, for the interest which he showed in the experiment and for the facilities which he gave for its smooth conduct, and to the British Hanovia Company for the loan of the necessary apparatus.

Twelve women employees of the firm, engaged in the manufacture of chocolates, volunteered for the experiment. This was divided into three observation periods: (a) a "pre-treatment" period of two weeks, (b) a "treatment" period of four weeks, (c) a "post-treatment" period of two weeks. Each girl was engaged throughout the entire experiment in making one and the same kind of chocolate, but the work of each differed in detail from that of her colleagues. The data of the output of each of the 12 girls were collected hourly throughout each of the three periods of observation. Three of the girls served as a control group. They believed that they were being given ultra-violet ray treatment, whereas in fact the ultra-violet rays were screened from them. Of the other nine girls one fell ill and was away from work for 17 days after three days' data had been collected from her during the pre-treatment period. Her records have therefore been omitted.

Treatment was given daily at 8 A.M. for four weeks. Of the 12 treatments the first four were on consecutive days, while in the second week three treatments, in the third week three treatments, and in the fourth week two treatments were given to each girl. Exactly the same procedure was carried out on the controls. The initial exposure was two and a half minutes for the whole body, back and front. Thereafter the exposures were increased gradually up to thirty minutes, according to the degree of erythema produced in each case. For the first four exposures each patient was treated individually with the air-cooled mercury-vapour lamp. Subsequently the girls were treated in batches of three at a time with the Jesionek lamps. The same lamps were used for the control group, but a sheet of "triplex" glass, 5/32 in. in thickness, was placed as a screen between the patient and the quartz burner. The absorption limit of this glass at this thickness being 3300, all the ultra-violet rays were cut off and no rays of shorter wave-length than 400 mm. reached the patient.

The findings had to be adjusted owing to the following circumstances: (1) During the pre-treatment and post-treatment periods of observation, the girls worked daily from 8 A.M. to 5.30 P.M. (with an hour off for dinner between noon and 1 P.M.); during the treatment period they began work at 9 A.M., as they were under treatment each morning between 8 and 9 o'clock. (2) At the start of each morning and afternoon spell of work the chocolate had to be tempered, so that the actual manufacture did not begin until 10 or 15 minutes later. (3) A rest pause of about four minutes was given during each spell of work. (4) A period of clearing-up occurred towards the end of each spell.* (5) Temporary absences from the room or from the works had to be allowed for.

TABLE I.

—	Pre-treatment.	Treatment.	Post-treatment.
A	96.6	90.0 } 97.4 } 93.7	108.0
B	110.2	107.6 } 108.9 } 108.2	117.0
C	103.7	110.0 } 107.4 } 108.7	107.6
D	117.8	120.7 } 119.1 } 119.9	122.0

The eight girls subjected to the ultra-violet rays, whose individual output throughout the three periods was regularly recorded, will be designated respectively by the letters A-H. They fall into two groups: (1) those whose output was evidently increased (A, B, C, D) upon exposure to ultra-violet rays;

* For this and other reasons the output during the last half hour of the day is not reliable; no records were therefore taken between 5 and 5.30 P.M.

and (2) those whose output showed no change (E) or whose output was reduced (F, G, H) as the result of the treatment. Of the latter group, it is noteworthy that H gave no reaction at all to the rays,

TABLE II.

Pre-treatment.	Treatment.	Post-treatment.
1st week .. 87.5	3rd week .. 90.25	7th week .. 92.75
2nd ,, .. 93.75	4th ,, .. 94.25	8th ,, .. 87.25
—	5th ,, .. 92.25	—
—	6th ,, .. 91.00	—

while E gave a fair reaction, and F and G gave only average reactions. On the other hand, of the group that responded favourably to the treatment, A, B, and C gave extremely good reactions to the rays, while D gave a fair reaction. Table I. gives the

TABLE III.

—	Pre-treatment.	Treatment.	Post-treatment.
F	90.9	85.7 } 84.7 83.7 }	84.0
G	73.5	71.15 } 69.7 68.25 }	69.0
H	86.4	82.6 } 80.9 79.2 }	84.1

average daily output in pounds per worker per fortnight. The total output of this group during the post-treatment period is thus 6.14 per cent. greater than during the pre-treatment period. The figure for A reaches 11.8 per cent.

TABLE IV.

—	Pre-treatment.	Treatment.	Post-treatment.
I	60.1	63.2 } 65.4 } 64.3	63.9
J	56.2	56.7 } 58.9 } 57.8	56.0
K	99.5	98.0 } 103.9 } 100.9	101.7

The Subject's Own Statements.

The girls' own statements about the results of treatment are interesting. A said that she felt better and wanted more of the rays. B was most

enthusiastic; she found that she had more energy and that she could settle down more easily to her work. She also asked for a further course of treatment. C declared that she had slept better and that her appetite had improved during treatment, but that she felt tired after it had ceased. D said that she felt distinctly better and wanted more. E, whose output gave no evidence of being affected by the rays, said nevertheless that her "nerves were better" after the treatment. But her output showed such wide fluctuations from week to week (as shown by the following data of average daily output) (Table II.) that no conclusions can be drawn.

F, a highly neurotic girl who was reported as "difficult" and unreliable, declared that she felt no better after the treatment; G was suffering from a cold both before and during treatment; H, who failed to give any cutaneous reaction to the rays, said that she felt no benefit. Table III. gives the average daily output of these girls per fortnight for the three periods.

The three girls of group (3), the control group, will be styled I, J, K. "I" claimed to feel better, but only while she was subject to "treatment"; her output improved correspondingly during that period, but fell off later. J felt little or no difference and showed practically none in her output. K, described as an excitable girl, fancied that she felt better for the treatment and showed a slight, but widely fluctuating, improvement, her average daily output during successive weeks being 98.75, 100.25, 95, 101, 106.25, 101.5, 100.5, 103. Table IV. gives the comparable data obtained for this group.

Any real improvements in the output of the girls of this group may be ascribed: (1) to suggestion, which was probably operative in I and K; (2) to the beneficial effect of other rays—e.g., infra-red rays, to which this group was daily subjected during the period of the "treatment"; (3) to practice. Mr. Brooke wishes to point out that an expert worker like J would not have had much recent experience of the particular "line" on which she was engaged throughout the experiment, but as her progressive rise in output was most manifest during the treatment period and fell off somewhat during the post-treatment period, her behaviour is also perhaps partly ascribable—although far less than that of I and K—to suggestion. According to whether we omit or include J, the percentage improvement in the output of this group is only 1.6 or 2.9.

Output of Workers who were Benefited.

The forms of the work curves of hourly and daily output obtained for each of the 11 girls during the three periods of observation confirm the results derived from the weekly data of output. The work curves of hourly output after treatment indicate for A a reduction of fatigue at the end of the afternoon spell; for C a reduction of fatigue at the end of the

FIG. 1.

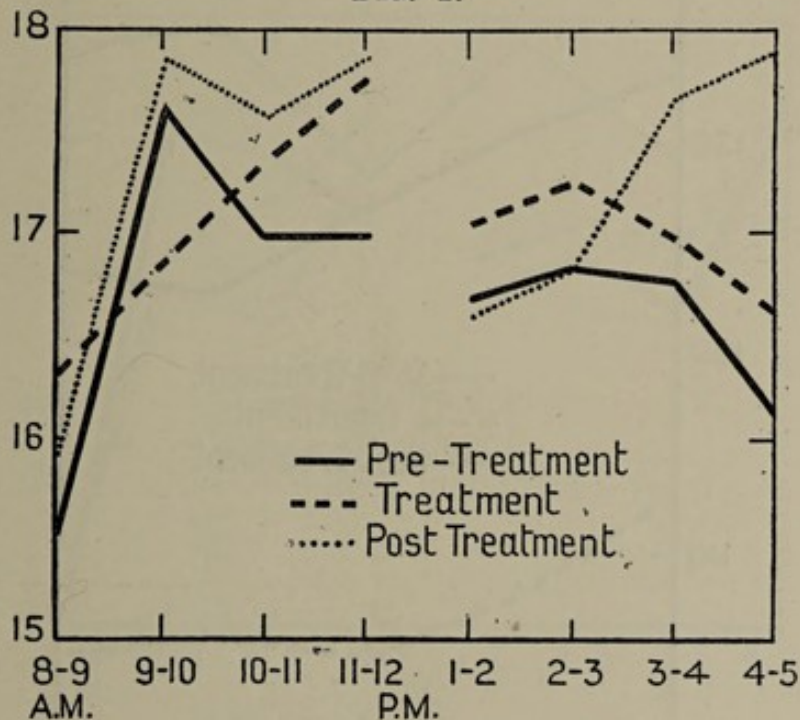


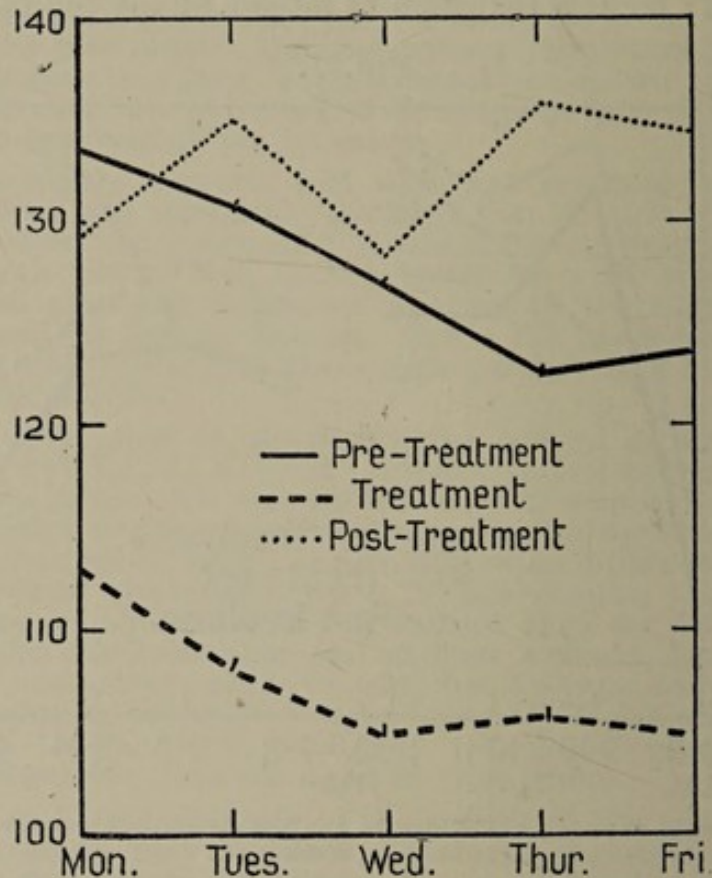
Diagram showing variations in the hourly output measured in pounds. (Worker D.)

morning spell; and for D a reduction of fatigue at the end of both spells. All these workers belong to the group whose output was increased by exposure to ultra-violet rays. The lessened fatigue at the close of each spell of work during and after treatment is illustrated in the case of D in Fig. 1. Instead of the fall that occurs in the continuous curve towards the end of the morning's and afternoon's work, the two dotted curves generally show a well-marked rise, indicating lessened fatigue and the ability to spurt as the work draws to a close.

Similar beneficial results are revealed by an examination of curves of the *daily* output of workers of the same group. After treatment A returns on

Monday keen and interested, and is thus more than able to counteract the loss of adaptation and practice due to the week-end absence. After treatment C shows less fatigue during the latter half of the week. D now reaches a far larger output than before on Thursdays. B manifests a strong tendency to

FIG. 2.



Variations in the daily output, of Worker B, measured in pounds. The "treatment" curve represents the output of a working day of *seven* hours, whereas in the other two curves an *eight* hour day is worked.

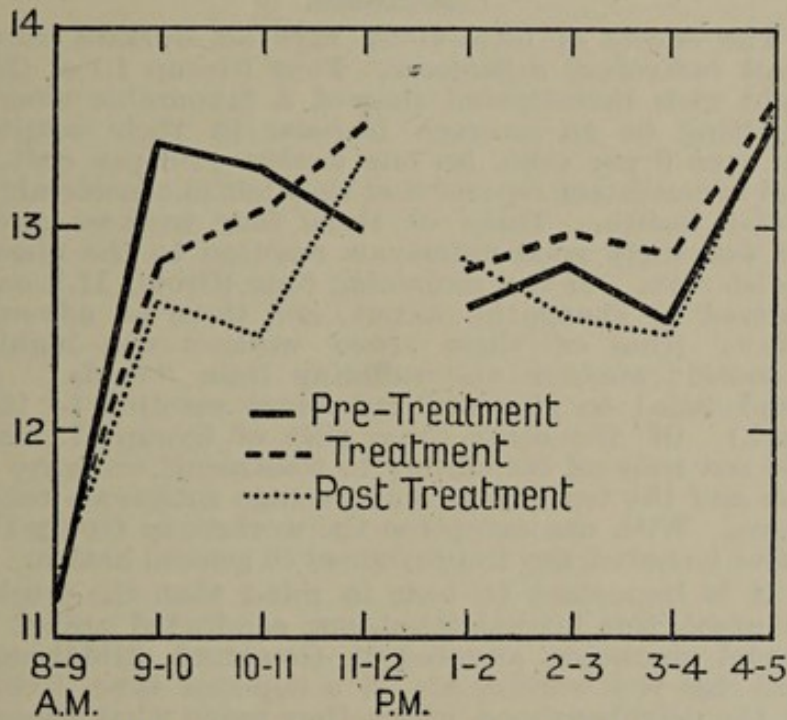
abolish her previous progressive daily diminution in output from the beginning towards the end of the week. This improvement is seen in Fig. 2.

The Output of Workers who were not Improved by Treatment.

A study of the curves of hourly output reveals in E after treatment a poorer start in the morning and afternoon, and greater fatigue towards the end of the afternoon; in F and G a poorer start in the morning,

in G greater fatigue in the afternoon, and in H a slower improvement or an actual lessening of output during the early hours of the morning and afternoon. The curves of daily output indicate in F and G a more adverse "Monday effect" after treatment. Accompanying these deleterious signs, there are certain tendencies which otherwise might have resulted in increased output. E, F, and G all show

FIG. 3.



Hourly output of Worker H, measured in pounds.

in the hourly output curves after treatment a speedy and progressive recovery from their initial bad start in the mornings. H shows an increased ability to spurt during the last hour, especially of the morning spell (Fig. 3). The daily output curve of E, whose output showed no clear evidence of increase after treatment, indicates a less marked fatigue towards the end of the week after treatment.

Control Group.

J showed a worse initial start in the morning and very little evidence of any effect of the pretended treatment in the hourly and daily output curves. K's daily output towards the end of the week fell off considerably during "treatment," but became far better after it, although worse at the start. During

"treatment" her hourly output curve showed a worse start, but reached a higher level in the afternoon; after treatment her output was higher towards the end of the morning and afternoon spells. I showed the same lessening of fatigue towards the end of the spells, and a more uniform output from Monday to Thursday. These differences, however, are slight and are probably ascribable to suggestion and to accidental variations.

Conclusions.

The effects of ultra-violet rays on workers show *great individual differences*. Four (Group I.) of the eight girls investigated showed a favourable effect, resulting in an average increase in their output by over 6 per cent. (in one worker 11.8 per cent.), and in consistent reports that they felt in considerably better health. Three of these four workers gave an extremely good cutaneous reaction to the ultra-violet rays. Of the remaining four (Group II.), one showed no change in output, and three an adverse effect. (One of these three workers was highly neurotic; another was suffering from "colds." A third failed to give any cutaneous reaction to the rays.) Of the other three girls of Group II. who did not respond favourably to treatment, one gave a fair and the two others only average cutaneous reactions. With one exception the workers in Group II. failed to notice any improvement in general health.

It is important to bear in mind that the works in which this investigation was conducted are of a model character, situated at Greenford, Middlesex, and that the workers are of a superior type, living in the neighbourhood where they enjoy what almost amounts to country sunlight. More striking results might be expected if the experiments were repeated on a larger scale in a factory in some poor district of a crowded city. The employment of a control group is essential.