The Other Shoe: An Early Operant Conditioning Chamber for Pigeons

Takayuki Sakagami¹ · Kennon A. Lattal²

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Abstract We describe an early operant conditioning chamber fabricated by Harvard University instrument maker Ralph Gerbrands and shipped to Japan in 1952 in response to a request of Professor B. F. Skinner by Japanese psychologists. It is a rare example, perhaps the earliest still physically existing, of such a chamber for use with pigeons. Although the overall structure and many of the components are similar to contemporary pigeon chambers, several differences are noted and contrasted to evolutionary changes in this most important laboratory tool in the experimental analysis of behavior. The chamber also is testimony to the early internationalization of behavior analysis.

Keywords Early pigeon chamber · Research apparatus · B.F. Skinner · Japanese psychologists · Technology and scientific change

In 1952, B. F. Skinner arranged with Ralph Gerbrands a shipment of operant conditioning apparatus to two universities in Japan: Tokyo University and Keio University (Skinner, 1983, p. 38). The two names in Japan that have been most prominently mentioned in the Keio shipment are M. Yokoyama and Takashi Ogawa, who were respectively professor and associate professor of psychology at Keio University at that time. Yokoyama traveled to the USA in 1950, supported by the Government Aid and Relief Fund in Occupied Areas GARIOA Program. During that trip he met, among others, E. G. Boring, who was in the Psychology Department at Harvard, and reportedly was impressed by American social psychology and animal psychology. He may have been introduced to operant conditioning apparatus during that visit, but this has not been corroborated. Asano and Lattal (2012)

✉ Kennon A. Lattal
klattal@wvu.edu

Takayuki Sakagami
sakagami.talayuki@gmail.com

¹ Department of Psychology, Keio University, 2-15-45 Minato-ku, Tokyo 108-8345, Japan

² Department of Psychology, West Virginia University, Morgantown, WV 26506-6040, USA

noted that both Skinner and Yokoyama thereafter attended an international congress in Stockholm (Skinner, 1951) and speculated that that encounter may have been part of the impetus for the apparatus arriving in Japan as well. Professor Masao Tachibana of the University of Tokyo did confirm that a rat chamber delivered to Tokyo University was purchased in April, 1952 for 259,000 Japanese Yen (which corresponds to 717.00 1952 US dollars or 2290.00 2016 US dollars). He also indicated that the chamber was discarded in 2008 (Tachibana, personal communication, March 27, 2015), following the fate of much old research apparatus. Asano and Lattal (2012) described the cumulative recorder that was shipped to Keio University. Here the other apparatus shoe to that discovery is dropped with a description of the operant chamber for pigeons that accompanied the cumulative recorder.

Early physical examples of operant conditioning chambers for either rats or pigeons are rare. One pre-1950s example of a rat chamber of the type described by Heron and Skinner (1939) is held in the Department of Psychology at the University of Minnesota. Although Skinner started conducting experiments with pigeons at the University of Minnesota in the days of what has come to be known as Project Pelican (Skinner, 1960), other than the Project Pelican apparatus (which is a part of the Smithsonian Museum's permanent collection) no examples of pre-1950s operant chambers for pigeons have been forthcoming, at the University of Minnesota or anywhere else. The early 1950s operant chamber for pigeons that was shipped to Japan as noted above was recently rediscovered in one of the operant behavior laboratories at Keio University in Tokyo. In the first part of this paper and in the Appendix we describe, in some detail for the historical record, this seminal apparatus for the experimental analysis of behavior. In the second part, we review some early uses of the chamber in Japan, putting it into the historical context of what would become behavior analysis in that country. In the third and final part, we discuss the chamber in the context of the broader history of operant chamber technology. We focus specifically on the differences between this chamber and ones that followed, and some of the implications of these differences for conducting an experimental analysis of behavior.

The Chamber

Figure 1 shows the exterior of the chamber. The shell is a J. C. Higgins™ ice chest. “J. C. Higgins” was a signature brand of sporting and outdoor equipment sold by the Sears and Roebuck Company of Chicago, IL between 1908 and the early 1960s. Then, as now, such ice chests were popular with picnickers, campers, and other outdoor enthusiasts, as well as with operant conditioners. Indeed, there are operant laboratories around the world that continue to use similar ice chests for chambers. This one is in excellent condition, although, as Fig. 1 shows, some of the brand-name decal has worn off. Its remaining part, however, still is readable. A label attached to the top of the chamber (Fig. 2) at some point in its past reads as follows: “Skinner box: It was sent from [donated by] Harvard University. Handle with care.” The chamber, when closed, is sealed except for a ventilation fan.

The interior of the chamber is shown in Fig. 3. The chamber is divided by a 3-mm thick aluminum panel into a work area, where the pigeon is placed, and a service area, where the response key, discriminative stimulus lights, reinforcement dispenser, and plugs to connect the chamber to the control equipment are located. Figure 4 is a pigeon's-eye-level view of the face of the work panel. Its most salient features are a single response key located behind the circular opening near the top center of the

Fig. 1 Exterior view of the operant conditioning chamber for pigeons. The cable resting atop the chamber makes the connection between the chamber work panel and the equipment used to program the contingencies to which the pigeon is exposed

chamber and a food magazine (also called a food hopper, feeder, or grain dispenser in laboratory jargon) located behind the square opening below the response key. The small dark circles are screw heads, and the dark bar across the middle of the panel is a brace.

Figure 5 shows two views of the service area. The two most unique and technologically interesting components in this chamber are the response key and the food magazine. The location of the response key is described in the Fig. 5 caption and the key is shown in more detail in Fig. 6. The center portion of the key, made of white plastic, is suspended such that when it is pecked through the circle on the work-area side (see Fig. 4), it closes a small switch, circumscribed by the rectangle in the right photograph of Fig. 6. Details of the key's operation are provided in the [Appendix](#), along with further description of the stimulus lights.

Fig. 2 Back side of the chamber showing the ventilation fan and the label indicating the chamber came from Harvard University (see text)

Fig. 3 Top view of chamber with the lid open. The *left photograph* shows the electrical components in the service area that translate the programs into specific experimental operations in the *lower portion* of the photograph and the wooden floor in the work area in the *top portion*. For orientation purposes, the *arrow* marks the top of the food storage bin. The *right photograph* shows the work area, where the pigeon is stationed during an experimental session, in the *lower part of the photograph* (the wooden floor was removed from the work area in this photograph). The rubber insulation around the top is marked by *two arrows*, which are joined together on the foam piece atop the work panel

The food magazine is shown in the left photograph of Fig. 7. The magazine consists of a frame that supports a vertically mounted storage bin (hopper) emptying into a horizontally mounted tray. At one end of the tray is an opening in its top side and at the other end is a lead counterweight. Reinforcement consists of raising the tray to a small aperture located behind and just below the square opening on the work-area side of the work panel (see Fig. 4). This is accomplished by operating an electric motor that turns the cogwheel (medium-length arrows in the left and lower right photographs in Fig. 7). The tray lifts when the raised portion of the cogwheel pushes on a lever attached to the tray (longer arrow in the left and lower right photographs in Fig. 7) and lowers when the indented portion of the wheel releases the lever.

Early History of the Chamber Use

Professor (Emeritus) Toshiro Yoshida unpacked the parcel containing both the operant conditioning chamber and the cumulative recorder (Asano & Lattal, 2012) when it arrived at Keio from Harvard via sea mail. He told the authors that there were no detailed explanations or instruction manuals accompanying the apparatus, making it difficult to understand the operation of both pieces of equipment. He recalled that the chamber was used first by Sukeo Sugimoto (at that time, a doctoral student in psychology who was supervised by Associate Professor Ogawa), but he did not publish his experiments using it. Both Professor Yoshida and retired Professor Satoko Ohinata (personal communication, 12 May 2015), who authored the experiment described below (and who also was supervised by Ogawa), noted that the box was difficult to use for flexible experimental conditions because the space within the box was so limited. They both also noted that the control equipment (probably electromechanical relays, timers, and counters) for displaying discriminative stimuli and magazine was so

Fig. 4 Front view of the work panel. The dark line across the middle of the photograph is a metal bar. The dark material at the top of the work panel is a foam rubber cushion that seals the front side of the chamber for the control equipment behind the work panel face. It is held in place on either side by two pieces of twine. The arrow denotes the electric plug described in the text

modest that the apparatus could only be used for relatively basic contingencies like simple discrimination, reinforcement schedules, or extinction.

The first published experiment based on research conducted using the chamber was conducted by Professor Ohinata (1955). The English version of the abstract of the paper reads in part:

The present study on the instrumental conditioning of color discrimination by pigeons was undertaken to determine whether the learning was based on absolute or on relative discrimination. It was assumed that if the learning was based upon

Fig. 5 The left photograph shows the rear of the work panel, with its electrical and mechanical components. On the left of the work panel is the (black) connection box, where the wires come in through the 12-prong male Jones plug (*arrow*) and then are connected to the other electrical components. To its right is the food magazine. Above the food magazine the two lights (housed in black plastic cylinders) used to transilluminate the key are visible, and in front of the lights mounted on the chamber wall and appearing as a partial rectangle is the response key. The *photograph on the right* shows a side view of the electrical components. The metal bars set at an angle are the support for the work panel. Behind the metal bar, the connection box is seen open, revealing two electromechanical relays and the electrical connections to other locations on the work panel. The male Jones plug protrudes from the lower part of the rear side of the connection box

relative discrimination, the luminance relation of the stimuli would be transferred regardless of their wavelength and, on the other hand, if it was based upon absolute discrimination, pigeons would respond to wavelengths without regards to luminance relations.

Fig. 6 The left photograph, showing a portion of the rear of the work panel, was taken from slightly above the plane of and to the left of the response key (the black and white partial rectangle is the response key). The two key-light sockets can be seen in the center foreground of the photograph (*shorter arrows*). The *longer arrow* points to an opaque shield that diffuses the light from the key lights. The *right photograph* shows the switch for the key, circumscribed by a rectangle, which closes to record a response when the key is operated from the other side of the work panel. The arrow points to the electrical contacts that close to define the response when the key is operated

Fig. 7 The left photograph shows the food magazine with its unique cogwheel (*longer arrow*) and lever (*mid-length arrow*) arrangement for raising the food tray to the level of the aperture, to which the pigeon has access. The key lights are marked in this photograph by the *shorter arrows*. The lower right photograph shows a closer view of the food tray raising mechanism. The lever is marked by the *longer arrow* and the cogwheel by the *shorter one*. The upper right photograph shows a slightly later Gerbrands design for a pigeon food magazine. Rather than using a cogwheel arrangement, the food magazine in the right figure uses a solenoid (*longer arrow*) attached to the food tray (*mid-length arrow*) by a spring (*shorter arrow*) to raise the tray to the aperture

The paper otherwise is written in Japanese, with only a few words written using the Latin alphabet; however, the following description of the apparatus is included: “装置: Harvard大学製鳩用Skinner-Box. 光刺激呈示のための附属装置は特に慶応義塾大学心理学研究室に於いて設備された。” (p 313). The words with Latin letters describe the present chamber and its origin. Professor Ohinata (personal communication, 12 May 2015) reported that the chamber continued to be used for a number of years for various undergraduate, graduate, and faculty research projects at Keio. One of these was conducted and reported by Professor Masaya Sato (1963) (the first president of the Association for Behavior Analysis International from outside the United States) related to deprivation level and discrimination performance.

The concerns noted above of Professors Ogawa and Ohinata with the limitations of the chamber probably relate to Ogawa’s dedication to comparative psychology. His interests in discrimination and perception were in that context. Thus, the early research involving the chamber was not focused on “operant conditioning” in the sense characterized by the work of Ferster and Skinner (1957), but rather on experiments and problems related to comparative psychology. The chamber had evolved in the USA to meet the emphasis and special needs of operant conditioning, which was concerned largely with the basic contingencies mentioned above (e.g., Ferster, 1953; Ferster & Skinner, 1957). It is interesting to consider the possibility that this chamber, along with the cumulative recorder and rat chamber mentioned in the introduction, may have created an environment in which operant conditioning could be shaped in Japan. Given

the kinds of research for which the chambers and recorder developed, it seems feasible that, with this apparatus available, research related to problems more typical of the experimental analysis of behavior might have developed through successive approximations as subsequent Japanese psychologists with different research interests came into contact with the apparatus. We know that the cumulative recorder Skinner shipped to Japan became the model for a Japanese-manufactured version of the cumulative recorder (Asano & Lattal, 2008). We do not know whether or to what degree the chambers of this shipment became models for construction of other chambers in Japan, but it is not hard to imagine that they did. As time passed there was increasing contact between Japanese and American psychologists of many theoretical orientations, but Skinner's shipment of apparatus can be considered among the factors leading to the development of Japanese behavior analysis.

Implications for the History of Operant Chamber Technology

The most striking thing about the chamber is its “modernity,” give that is more than 64 years old. With the exception of the response key and food magazine, described above, this chamber could as readily be used in any behavior analysis laboratory today as one built in the past year. Indeed, its functions are identical to its contemporary counterparts. This could, and probably will be, taken by some as evidence that the research methods of the experimental analysis of behavior are too entrenched, stuck in the halcyon days of “operant conditioning” with only a dim future ahead. An alternative perspective, which we prefer, is that Skinner developed a powerful tool when he invented the operant conditioning chamber. Its utility persists, and we have only begun to exploit its potential to enhance our understanding of behavior.

The overarching function of an operant chamber, then and now, is to provide a more or less constant, distraction-free environment in which the interactions between organism and environment can be studied. Such isolation requires that the chamber be ventilated to maintain a constant, comfortable temperature for the animal (see Ferster, 1953). This was accomplished by the ventilation fan described above; however, the location of the ventilation fan resulted in it pulling air across the pigeon in the work area and then the service area before exhausting through the fan. This design resulted in more exposure of the mechanical and electrical control and recording devices in the service area to more pigeon dust (the lubricant generated by the pigeon's feathers) than would occur had the ventilation circulation been reversed. This problem was not always recognized even by later commercial manufacturers, who often similarly placed the ventilation fan as it is in this chamber. A quick perusal of the pigeon chambers in two of the operant laboratories at West Virginia University uncovered four different commercial models of pigeon chambers, three manufactured in the 1960s and 1970s and one after 2010. Tellingly, all were vented as this chamber. By contrast, all of the home-made chambers were vented such that the exhaust was in the work area rather than the service area.

Except for the fan, the chamber is completely isolated from the external environment when it is closed. One consequence of this is that there is no way, short of leaving the lid open, to observe the animal in the chamber. The early rat chamber housed at the University of Minnesota's Department of Psychology is similarly completely isolated, because it too lacks any means by which the behaving animal can be seen when the

chamber is closed. Even though Skinner developed many demonstrations in which the animal was placed in an open environment for all to see (one of these environments is shown in a popular photograph of him, see Skinner, 1979, photographic display between pages 184 and 185 that is labeled “Demonstrating operant conditioning of a pigeon, Indiana, 1948”). The balance between the risk of disturbing the animal while working and the need to see what the animal actually is doing was later resolved in the construction of pigeon and rat chambers by including a means for observing the animal when the experiment was in progress. In earlier days it might have been a glass- or plastic-covered aperture with a curtain over it that could be lifted to allow the experimenter to watch the pigeon. Or it could have been a peep hole of the sort found in entry doors of homes and apartments. Today it often is a miniature camera mounted in an unobtrusive spot inside the chamber. The absence of a means of seeing the subject directly in these early chambers made it impossible to observe behavior other than the recorded operant. The absence of an observation port early in the history of operant conditioning may have contributed to an unfortunate behavioral precedent for some experimenters and laboratories of not only ignoring, but perhaps even dismissing, observational data as too subjective and of limited value. Although there have been many demonstrations to the contrary (e.g., Laties, Weiss, Clark, & Reynolds, 1965; Staddon & Simmelhag, 1971), precedents sometimes are hard to undo. Perhaps our science would be further along had some of the time spent mesmerized by cumulative records been spent looking through observation ports and peep holes to see what was going on that was not always reflected in those cumulative records.

Cumulative records were created by routing the electrical impulses generated when a response key was activated to a cumulative recorder (Lattal, 2004). To do this, a switch closure was required. That switch was the response key. Close inspection of the actual switch circumscribed by the rectangle in the right photograph of Fig. 6 reveals it to be a normally open switch (arrow). This means that operation of the key created an electrical pulse that in turn could be translated to a standard duration (usually 50 ms) and then counted with an electromechanical counting device and/or routed to the cumulative recorder to “step” the response pen one unit with each switch operation (Lattal, 2004). The electrical response pulse also operated programming devices that delivered the reinforcer. It takes longer to close a switch than it does to open one. Skipping the electronic details, suffice to say that normally open circuits soon were discovered to simply not be fast enough to accurately capture the pecks operating the key switch. So, at some point normally open response keys like the one on the present chamber were replaced by response keys that operated when a circuit was broken rather than “made.” This change greatly improved the capture of responses by the electromechanical circuitry; making the obtained data more closely reflect the actual key pecking of the pigeon (though still not always with 100 % accuracy). Contemporary use of touch-screens to record pecking responses of pigeons, when they work properly (a caveat for any item of equipment, of course), allow recording of the location of the response relative to the target area. So-called “off key” pecks occurring when a switch-type response key is used are lost without special techniques to capture them (e.g., Dunham, Mariner, & Adams, 1969). Modern response key technology also can allow for the possibility of capturing variations in response force (ordinary response keys that are switches require a minimum force and cannot differentiate between force requirements

above or below that limit). The upshot of this is that the key in this chamber is truly a dinosaur, one of an earlier era that has been extinct for a very long time.

The other unique feature of this chamber noted above, is the food-magazine operation system. By the time Ferster (1953) published his description of the methods of operant conditioning, food magazines of the sort on this box were, as far as we can tell, extinct. A typical food magazine of the mid 1950s is shown in Ferster and Skinner's (1957) Fig. 2 and in the previously described upper right photograph of Fig. 7 previously described. The skeleton of the latter and the one on the work panel of this chamber are almost identical. Both consist of a food storage bin that releases grain into a food tray. The food tray is connected to a device to raise the food tray to an aperture at the base of a chute through which the pigeon could stick its beak and obtain a few bits of food. The present food magazine accomplished the raising of the food tray by the cogwheel mechanism as described above. The one shown in Ferster and Skinner's Fig. 2 and in the upper right photograph of Fig. 7 above accomplish the raising by activating a solenoid attached to the food tray by a spring. This activation pulls the food tray up into position such that access to the food through the aperture is possible. We can only speculate as to the reasons for the demise of the cogwheel mechanism. One possibility is that it was too large. The motor that operates the cam is bulky and covers most of the area above the food tray, but it does not seem to obstruct anything. A second possibility is that the cogwheels did not operate reliably. There is no evidence one way or the other on this. The cogwheel on the present food magazine appears to be quite sturdy and, when operated manually, raised and lowered the food magazine with precision. A third possibility is that the motor operation was not sufficiently loud to result in reliable eating. That is, the raising of the food magazine did not function as a conditioned reinforcer. Iversen (personal communication, 2013) found with contemporary "silent operation" pellet dispensers for use with rats that the rat often left the food pellets in the tray after they were delivered. Only when he added a sound that occurred simultaneously with the dispenser operation did the rats rapidly approach the food cup and consume the pellet. A silent feeder could be an even greater problem with pigeons, because, unlike a pellet that stays in the food cup after it is delivered, grain is available only so long as the food tray is raised. The effect of a silent motor, however, would be compensated for by the fact that there is a light above the food aperture that presumably operated when the magazine motor was operated. A fourth possibility is that changing the duration of the reinforcement cycle would have required changing the cogwheel, because the magazine is raised so long as the upper portion of the cogwheel is in contact with the lever. Thus, reinforcement duration is fixed by the length of the upper portion of the cogwheel such that changing reinforcement magnitude would require replacing the cogwheel with one configured another way. A final possibility is that solenoids were cheaper than the cogwheels, which, as noted, required an electric motor to operate. The solenoid, however, required an independent timing device external to the chamber to hold current on the solenoid throughout the reinforcement cycle. Thus, whatever monetary savings there was in using the solenoid may have been offset by the need for an external timer. It is difficult to assess after the fact which, if any of these factors contributed to the switch to solenoids. Whatever the reason, the solenoid has been an enduring feature of pigeon food magazines up from their first use in the 1950s to today.

Solenoids in early chambers typically were operated by a 110-v AC current. Indeed, most of the early electromechanical programming equipment operated off of this high voltage (Catania, 2002; Dinsmoor, 1990). These solenoids created no problems with most electromechanical circuitry of the era of this chamber, but when, beginning in the early 1960s, transistorized circuitry began replacing or complementing electromechanical equipment in operant conditioning laboratories, problems arose because of the electrical interference created by the operating and deactivating of these high-voltage solenoids. This interference caused transistors to operate at unscheduled times, thereby disrupting programming and recording equipment. These relatively high-voltage solenoids eventually were replaced by ones that were operated by a 28-v DC current, which generally did not disrupt sensitive equipment. These remain the standard today.

We also should comment on the lights for transilluminating the response keys, which thus served as discriminative stimuli. We could not discern whether the lights were operated by a 110-v alternating or 28-v direct current. The generation of chambers in the era of Ferster and Skinner (1957) commonly were equipped with low-wattage 110 v AC Christmas tree lights as the discriminative stimuli. These lights were used because 28 v DC lights used to transilluminate response keys would flicker due to voltage fluctuations when the key was pecked and recorded or even when reinforcers were “set up” by the electromechanical equipment used to control the experiment. The result of this could be to provide a reliable visual cue as to the availability of a reinforcer, with the effect of undermining the experiment. Low-voltage (28 v DC) bulbs came into use only when it was feasible to operate them from a second power supply that operated independently of the one controlling the relay programming apparatus. Enclosed “pilot lights” located directly behind the key—typically much closer than the distance between the lights in this chamber and the back of the response key—offered some protection of the lights from the fine covering of pigeon dust described above. The most contemporary device for presenting discriminative stimuli is a computer screen, which offers the investigator almost unlimited control over the type, and location, of these stimuli.

Conclusion

Over time, this pigeon chamber found its way to the back of a shelf in an operant laboratory at Keio University, where it lay fallow until it recently was retrieved by the first author after an inquiry by the second. It is a truly rare item and as such is an important part of the collective heritage of our discipline. Beyond its obvious significance in the history of the experimental analysis of behavior, the chamber also is testimony to the strong international connections between behavior analysts, exemplified by the one between the early Japanese behavior analysts and Skinner that helped bring mid-twentieth century cutting-edge behavioral research apparatus to Japan.

Appendix

Details of the chamber omitted from the general description in the section above labeled “[The Chamber](#)” appear in this Appendix.

The Chamber Shell

The exterior dimensions of the aluminum chamber are 56 cm long by 41 cm high by 33 cm wide. There are latches at either end (part of the latch on the work-area end is missing), centered on the short sides of the chest. Except for the attachment of a ventilation fan and a single aperture to accommodate the electrical cable, the chest otherwise looks like any other of this product line. The connecting cable that protrudes from the work panel through the rear wall appears to be original. It is 180 cm long, excluding the male Jones plugs (12 prong) connected to either end. The connector at the end distal to the chamber was attached to either directly to the programming apparatus or to a female connector, which in turn attached to another cable that connected to the programming apparatus that controlled the contingencies to which the pigeon in the chamber was to be exposed. The cable covering is of a heavy fabric, rather than the later plastic cable coatings/coverings. The ventilation fan (shown in Fig. 2 on the rear long side of the chamber) is powered from a plug that connects through the ice chest wall to another plug located on the back side of the work panel. The fan housing is 11.5 cm long by 8 cm high, and protrudes 9.5 cm from the outer wall. It is powered by a 110 v AC motor, manufactured by Fasco Industries of Rochester, NY (model number 507451N (the last letter is slightly marred, so it could be another letter). The opening for the fan on the inside of the chamber is 15.5 cm from the top and 9.5 cm from the rear wall of the service area. The hinges for the chamber lid are located on either end of the lid, as can be seen in the right photograph of Fig. 3. Attached around the inside perimeter of the lip of the ice chest is a rubber gasket (indicated by two arrows in the right photograph of Fig. 3), which has come unattached in several places, but is not deteriorated.

The inside of the chamber is 50.5 cm long by 28 cm wide by 33 cm high. It is divided by an aluminum panel (hereafter, the work panel) into a work area (where the pigeon is placed), shown at the top of the left photograph and at the bottom of the right photograph of the chamber in Fig. 3, and a service area, shown at the bottom of the left photograph and the top of the right photograph in this figure. The work area measures 32.5 cm long by 28 cm wide by 33 cm high and the service area 18 cm long by 28 cm wide by 33 cm high. The opening for the ventilation fan is on the right wall of the service area (when viewing the rear of the work panel from the service area), as shown in the left photograph of Fig. 3. The floor of the work area is covered by a piece of wood, raising the work area by 3.8 cm, but it could not be determined whether this was part of the original design or was added later. We speculate that it may have been added in Japan because Japanese pigeons may not have been as tall as the ones used in the USA. If so, this may have made it more difficult for the pigeons to reach the response key.

The Work Panel

The work panel, shown in Figs. 4 and 5, is 27.2 cm wide by 32 cm high. Figures 4 shows a piece of black foam rubber (somewhat deteriorated, and difficult to determine whether original or added later) across the top such that it covers the small space that otherwise would exist at the top of the work panel between the work and service areas of the chamber (thus accounting for the difference in the

chamber height and the work panel height). The foam is seen most clearly in the left photograph of Fig. 3, where the twine holding it onto the work panel also can be seen. The response key is located behind a 7.1 cm diameter opening, the center of which is about 26.8 cm from the chamber floor (23 cm from the wooden platform floor), on the midline (13.6 cm from the left wall) of the work panel, shown in Fig. 4. Below it is the food magazine aperture through which grain can be accessed. This aperture is 5.2 cm high by 5.6 cm wide, with its center also on the midline of the panel (13.6 cm from the left wall) and about 9.7 cm from the chamber floor (5.9 cm. from the floor of the wooden platform).

There is no means of providing general illumination through devices built into the panel; however, there is a small two-prong electric plug in the top right corner of the work panel (Fig. 4, arrow), with an unconnected wire attached to it. Inside the chamber in the work area are two candelabra type 100 v lamp holders (one of the holders contained a 110 v bulb) placed unattached on the floor directly below the loose wires. These can be seen in Fig. 3 in the upper right corner of the work area shown in the right photograph. The wires connected to the two candelabra bases appear to be old, but it cannot be determined whether they and the bases were original or not. The insulation on the wires is not plastic; rather, they are of the same fabric material as the afore-described cable wire, seemingly revealing something of its age. Whether these constituted a houselight for general illumination of the work area is not known.

Figure 5 shows rear (left photograph) and side (right photograph) views of the control side of the work panel. The single sheet of aluminum that comprises the panel is bent at a 90° angle such that its base covers the floor of the control area. The panel is braced by (now) rusty iron bars set at an angle and attached to the side lip of the work panel and its base, apparently to prevent the panel from coming out of position in the chamber as the pigeon pecks the key (there are no grooves for holding the work panel or other means of stabilizing it in the chamber). A similar, but horizontal, iron bar braces the panel from the work-area side, as noted in the “[The Chamber](#)” section above. The wiring and solder connections on the control panel appear to be original, although it is difficult to determine whether some of the connections have been re-soldered. Many of the individual wires leading to various components, however, are bundled with a wire binder holding them together and they appear to be unmodified over the years of the chamber’s residence at Keio. Located on the work panel are a connection box to which the cable connects, a response key, two stimulus lights used to transilluminate the response key, and a device for delivering mixed grain through the aforementioned aperture on the work-area side of the work panel.

A metal connection box is located in the lower left corner of the control side of the metal panel (viewing from the control area; see the left and right photographs of Fig. 5). The connector cord (connecting the box to the programming and recording equipment) is plugged into the box through a male Jones plug visible at the lower rear of the box. The box contains two 2-pole double-throw relays, function unknown. These relays sometimes were used to channel power to lights or food magazines. Some of the wires from the male 12-prong Jones plug connector go through these relays, but other wires go directly from the Jones plug connector to the various components.

Response Key

The response key, shown in Fig. 6, is composed of a 6.5 cm square piece of thin black plastic on which is mounted a piece of white opaque plastic (6.4 cm high by 4 cm wide). The unit is located behind the circular opening in the work panel. The white plastic piece is unhinged and can move off its fixed location in four directions. There appears to be a small spring attached to the bracket at the top of the key assembly that holds the white, moveable portion of the key in place and ensures the return of the key to its neutral position at the end of each peck. The face of the key (the pecking surface) is recessed about 3 mm from the face of the work panel. The force requirement of the key does not appear to be adjustable. The key operation is described in the “[The Chamber](#)” section.

Stimulus Display

As noted above, the two stimulus lamps are shown in the left photographs of both Figs. 6 and 7 as the two black cylinders (marked by the short arrows, above the food magazine in Fig. 7). The one on the right (from the rear of the work panel) is placed above the plane passing through the center of the key aperture and the one on the left is placed below this plane. Their location is precise and they do not appear to have been added later, suggesting that this arrangement was part of the original chamber design, although some of the wires connected to the lights may have been cut and re-soldered. It was difficult to determine by visual inspection whether these jewel lamps (pilot lamps) were 24 v DC or 110 v AC. Twenty cm in front of the lamps is a piece of frosted glass (Fig. 6, left photograph, longer arrow), perhaps used to diffuse the light coming from the key lights and diffuse it evenly across the response key. The frosted glass is 65 mm behind the response key.

Food Magazine

The food magazine is shown in the left photograph of Fig. 7. It is located behind the square aperture on the work-area side of the work panel. The cogwheel and lever are shown in the lower right photograph of Fig. 7. The details of its operation, and a comparison of it with the later Gerbrands model shown in the upper right photograph of Fig. 7 are described in the “[The Chamber](#)” section above. The cogwheel is rotated by a 110-v AC synchronous motor, which is not readily visible because of the cogwheel. We could not determine whether the motor operates from a single pulse and continues to operate through a reinforcement cycle or whether continuous application of current to the motor is required to ensure raising and lowering of the food tray. There is a light above the feeder aperture that presumably illuminates with the operation of the magazine.

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Author’s note

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