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Electronic Behavior-Event Counters

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Use rate of response (frequency, or count per unit time) as a dependent variable is one of the essential features of behavioral analysis (e.g. Glenn & Madden, 1995). Lindsley (1992) and others (e.g. Johnston & Pennypacker, 1980; Johnston & Pennypacker, 1993) have also extensively discussed frequency and celeration (count per unit time, the derivative of frequency). Selectionism views of life as series of behavioral events in time, making frequency a convenient and natural metric for the measure of any class of behaviors, and celeration the simple measure of change in frequency. Frequency rests on counts and measures of time. The present paper discusses some inexpensive electronic frequency counters suitable for personal, clinical, and experimental use to help measure frequencies and change behaviors.

In 1968, Lindsley reported the use of a mechanical "wrist" counter designed for golfers as a behavioral counter. While these counters remain in use, some problems have surfaced with some varieties of mechanical counters. First, the counters offer only two digits, incrementing up to 99 and then rolling over to 0. Second, the operational quality of mechanical counters varies; some samples do not increment reliably with each push of the plunger. Finally, the design of the case does not allow easy attachment to every wristband. Recently, digital electronics have become available as consumer products that offer the counting function. Several of these products are discussed below. An advantage of the digital counter is that different variations of switches can be easily attached to increment the counters.

Sports Counters

An inexpensive ($20) digital counter designed for sports use has recently become available (Sport Counter Sportline, 847 McGinty Ln., Campbell, CA 95008). This instrument is designed to be worn on the index finger and operated with the thumb, but it can easily be mounted on a watch band or belt. It measures approximately 2 x 2 x 2 cm. The SportCount also incorporates a digital watch. A more expensive model (approximately $35) also includes a stopwatch and will track some summary statistics (including total elapsed time, longest IRT, shortest IRT, and average IRT) although it unfortunately does not calculate frequency. Both SportCount models feature a larger "count" button and a smaller "reset" button that can be distinguished by touch. A firm press "bottoms out" the "count" button giving tactile feedback for each count.

Pedometer conversion. An inexpensive digital pedometer (Radio Shack #63-682, approximately $10) can easily be converted into a convenient and accurate counter. Procedures for conversion of the Radio Shack model into one of four types of counters are given below.

Radio Shack Catalog #63-682 measures approximately 3 x 4 x 1 cm. The case is secured with a small Phillips head screw. To open the case, follow directions given for changing the battery. Inside the case (see appendix A), one finds a pendulum in the form of a weight on the end of a pivoting arm, and a contact point connected to the battery that just touches the weight at the full excursion of the pendulum. The display increments each time the pendulum weight touches the contact point. To convert the pedometer into a digital counter, one may simply arrange to control the movement of the pendulum to the contact. Each type of counter discussed below accomplishes this basic task in a different way.

Push-pull counter. Construction of this simple counter involves connecting an L-shaped push-pull rod to the pendulum such that pulling out on the rod will move the pendulum arm to open the contacts, and pushing in on the rods moves the

pendulum to close the contacts, incrementing the counter. The rod protrudes through a hole melted or filed in the case. Fortunately, the pendulum arm is manufactured with a hole for a spring near the free end; this spring anchor hole is conveniently placed and sized to accept a common straight pin with a right-angle bend near the sharp end that will function as the L-shaped push rod. One may measure the appropriate length for the pin by holding the pendulum in the "contact" position and laying the pin across the counter, with the pin's top protruding over the display and across the edge of the counter. The sharp end crosses the pendulum at the hole. Bend the pin at a right angle where it crosses the hole in the arm. Then insert the sharp (bent) end of the pin into the hole in the pendulum arm. When the pin is pushed along its axis toward the center of the counter, the pendulum is forced down to make contact. A mark should also be made in the counter's case where the pin crosses the case wall. Then, melt or file a notch in the case wall to allow egress of the pin when the top of the case is replaced. Pins with globular plastic heads seem to work well.

Spring-loaded Push Counter. Same as the Push-pull counter, except that a spring arrangement is added to hold the pin in the outer or "ready" position. Thus, it is operated by a push and the spring returns it to a ready position. To make this variant, simply cut the pin to length so that it protrudes about 6-8 mm from the case. A section (about 4 mm) of the spring from a retractable ball-point pen seems to work well to return the pin to the "ready" position. To prevent the spring from slipping over the pinhead, a washer may be fashioned by using a hand punch to punch a hole in a discarded credit card or similar thin plastic object. Then, take the circular punched-out piece and melt or drill a small hole in its center to accommodate the pin. Place the washer, then the spring, on the pin and insert the short arm of the L into the pendulum. When the pin is pushed in, it will move down to make contact; when released, the spring returns it to the fully extended position. Check carefully and adjust the pin length and washer so that counting is reliable; with some counters modified in this way, the count is accurate if one depresses and releases the pin, but a double count may by registered if one depresses and holds the pin, then releases it due to "bounce" or multiple contacts.

General counter - any switch. A wide variety of single-pole single throw (SPST) switches can easily be wired to this pedometer to make a self-powered, unobtrusive counter. The use of a magnetic reed switch would allow non-contact switching, such as for counting bicycle or wheelchair spoke rotations (Halstead, 1973, 1976). For a wrist counter, an attractive arrangement could involve cementing a dome-type switch to the surface of the pedometer. For all of these applications, simply open the case and clip the weight off of the pendulum arm, using a diagonal cutter or similar tool. Drill, file, or melt a notch of whole in the pedometer case to accommodate the leads to the switch and thread the leads through the hole. Then, solder one lead of the switch to the battery holder and the other to the remaining potion of the pendulum arm.

Micro-switch wrist/belt counter. At least one momentary contact switch is small enough to be mounted in the cavity that remains after the pendulum weight is removed, but the switch can be left protruding from the case. Follow directions above and clip off the weight. Then, file or melt a hole into the cavity that house the weight from the edge of the case. A semi circle can be cut into both the top and the bottom edge of the case, such that the case can almost be closed around the switch (the switch is just a bit too large for a perfect closure). Then, the lead of the switch are bent, such that one can be soldered to the stub of the pendulum arm and one to the battery case contact. The commercially available switches generally have a better "feel" and give distinct feedback when the make contact, as compared to some "homemade switches". Commercial switches are also generally engineered to have no "bounce" in the contacts that can lead to double counting.

Reliability Of The Counters

All of the counters were systematically assessed for reliability. Each was pressed 100 times, while the second researcher counted numbers out loud while looking away from the counter. After 100 presses, the number on the display was recorded. 100 more presses were counted and again the number on the display was recorded.

All of the counters proved to be reliable in the testing period. If the plungers on the counters are pressed solidly, the reliability is very good.

The Micronta and the Borm showed accuracy ratings greater than 97%. The accuracy of the Sport Counter was greater than 99%. When using any of the counters, the accuracy can be increased by pressing the buttons firmly and slowly and releasing the plunger completely. If this is not done, the accuracy may be reduced.

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Pedometer to Counter Conversion