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TREE CHIPPER HUMAN PERCEPTION-REACTION TESTING

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Abstract: This paper examines human perception-reaction response during a branch pull-in scenario involving a commercial mechanical infeed tree chipper. Tests were performed with ten human adult male subjects utilizing an infeed hopper test fixture equipped with feed wheels and a safety control bar located close to the feed end within easy reach of the test subject. The test results indicate that all ten test subjects were able to move the safety control bar into the reverse feed wheel position before their hand attached to the branch entered the feed wheels.

1. INTRODUCTION

1.1 Commercial Mechanical Infeed Tree Chipper Description

Previous research has studied the safety of commercial mechanical infeed tree chippers during pull-in scenarios (Brickman, 2002 & Brickman, 2003). This paper investigates whether the perception-reaction of unimpaired human adult male test subjects can move the tree chipper safety control bar into a reverse feed position before their hand attached to a branch enters the feed wheels. A commercial tree disc chipper infeed hopper with a mechanical infeed system is shown in Figure 1. During the feeding mode, the operator will manually feed the tree branches into the infeed hopper to the feed wheels which in turn bring the branches to the cutting disc. A series of 60 tests were performed utilizing ten human adult male test subjects and a commercial tree chipper mechanical infeed hopper test fixture.

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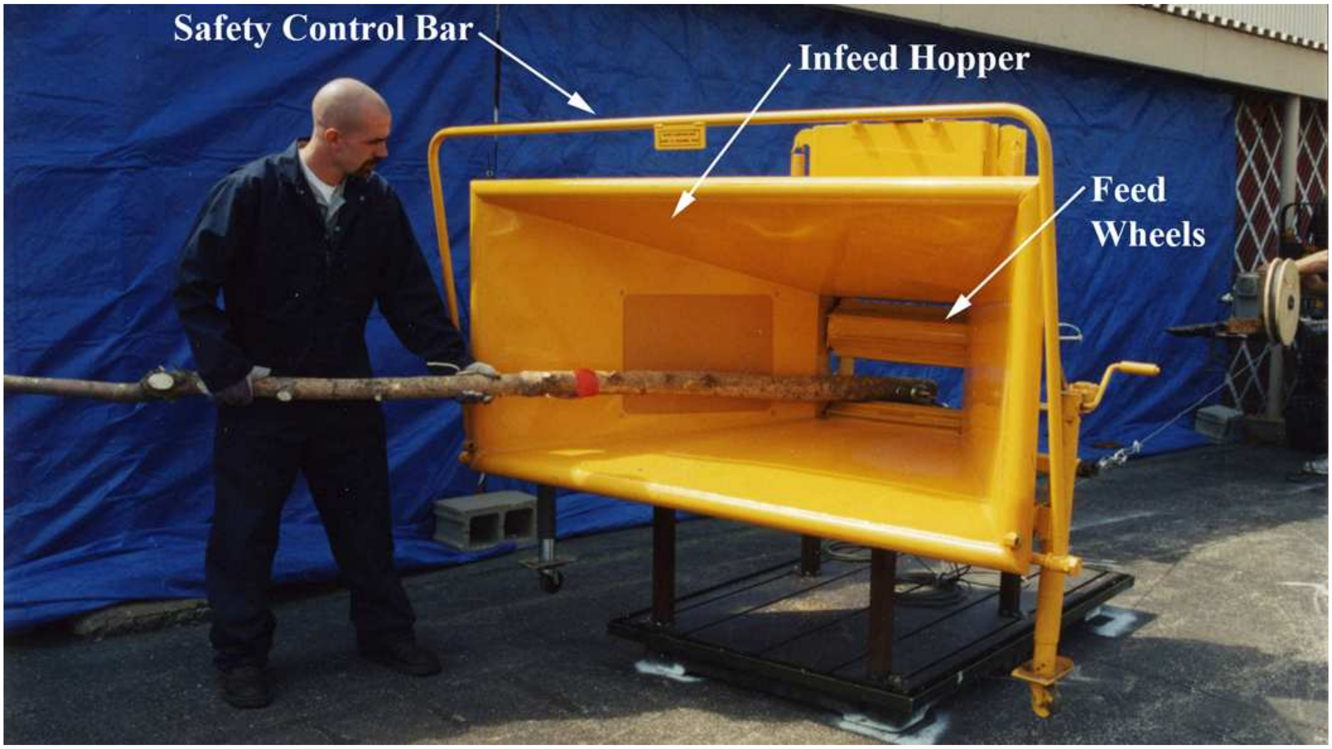

Figure 1. Commercial Tree Disc Chipper Infeed System

1.2 Origins and Types of Perception-Reaction Time Measures

Donders published one of the first studies of perception-reaction time in 1868. Over time, three different variations on reaction time experiments developed (Welford, 1980). The initial protocol (*simple reaction time*) was to ask the test subject to attend for a stimulus and respond in one way when the stimulus presented. Later, two variations on this protocol were developed. In the *recognition* reaction time experiments, subjects were asked to attend for specific stimuli and *only* give the response when one of the previously identified targets was given. The effects of factors like distractor similarity to the actual target stimulus, as well as the frequency of the stimulus against the background "noise" were extensively studied. As one might expect, subjects respond more quickly when the stimulus is more clearly discriminable from the background noise. The impacts of these factors is well summarized by texts which cover signal detection theory such as *Engineering Psychology and Human Performance* (Wickens and Hollands, 2000). In the *choice* reaction time protocol, subjects are instructed to take one of several actions depending on which stimuli are presented. Predictably enough, as the number of different possible stimulus-response pairs increase, the time to respond also increases. This finding is known as Hick's Law (Hick, 1952).

In laboratory settings, measured reaction times are typically less than 250 milliseconds, but do vary somewhat by stimulus modality. Mean auditory reaction times are reported to be 140-160 milliseconds, while mean visual reaction times being 180-200 milliseconds (Welford, 1980). Reaction time to a tactile stimulus falls somewhere in between, around 155 milliseconds (Sanders, 1998). Of course, reaction time data for more "real world" applications may be somewhat longer.

In an earlier publication, Pattie (1973) measured the reaction times of subjects to a horn warning of an impending tractor overturn. Four different control devices were assessed: a foot clutch, an extended toggle switch, a horn ring switch, and a rim blow switch. A continuous tracking task was used to decrease anticipation by the test subjects. Mean perception-reaction times across conditions ranged from 304 to 665 milliseconds. For the condition with the longest response time (695 milliseconds), the corresponding standard deviation was 120.2 milliseconds. These data strongly suggest that an unimpaired and reasonably attentive operator should be able to actuate the safety control bar on a tree chipper in considerably less than 1.5 seconds after his or her hand begins to be pulled past the vertical plane of the infeed hopper. The testing data presented below confirm that in all trials conducted the test subjects were in fact able to actuate the safety control bar in less than 1.5 seconds.

2. TEST PROGRAM

2.1 Test Subjects

The testing program was conducted with ten human adult male subjects ranging from 68 to 73 inches in height and 130 to 200 pounds in weight. These test participants had no previous commercial tree chipper operating experience. The height and weight attributes for each test subject are displayed in Table 1.

Table 1. Test Subject Physical Data

Test Subject	Height (Inches)	Weight (Pounds)
1	70	170
2	68	167
3	70	190
4	73	195
5	68	200
6	69	130
7	71	170
8	69	155
9	71	180
10	73	165
Ave.	70	172

2.2 Test Procedure

The test fixture was equipped with a safety control bar located close to the feed end of the infeed hopper within easy reach of the test subject in accordance with the requirements of ANSI Z133.1-2000 (ANSI Z133.1-2000). The distance from the leading vertical plane of the infeed hopper to the horizontal centerline of the feed wheels was 36 inches. The bottom of the infeed hopper was located 22 inches off the ground. The test branch was 106 inches long and measured 3.5 inches in diameter at the butt end.

The initial position of the test subjects had both feet on the ground with their torso facing the infeed hopper. One of the test subject's gloved wrists was attached to the branch by a rope. The remaining hand held the branch further away from the feed wheels than the tied hand. Each hand of the test subject was attached to the branch for three tests where the test subject was positioned at the left, center, and right of the infeed hopper. Each test subject participated in six tests.

The test started when the branch was pulled into the infeed hopper at a constant rate of 120 feet per minute by a cable attached to a motor. No verbal cue or visual signal was given to the test subject at the beginning of the test. Each test subject attempted to move the safety control bar with his free hand to the reverse position as quickly as possible after feeling his attached hand being pulled by the branch toward the feed wheels. The test terminated when the test subject moved the safety control bar to the reverse feed wheel position with his unattached hand.

2.3 Test Results

Figures 2 through 7 exhibit representative test sequences for the six different test trial conditions. These six test sequences reflect the test subject number, the hand attached to the branch, and the position of the test subject relative to the feed hopper. The first scene displays the starting position with the test subject's attached leading hand located at the vertical plane of the infeed hopper. The second scene depicts the test subject's attached leading hand being pulled into the infeed hopper towards the feed wheels. The final scene shows the test subject pushing the safety control bar forward into the reverse feed direction with his free hand. The test results indicate that all ten test subjects were able to perceive that their attached hand was being pulled, react to their attached hand being pulled, and move the safety control bar with their free hand into the reverse feed wheel position before their hand attached to the branch entered the feed wheels during the 60 trials. In every case, the perception-reaction time associated with each test trial was considerably less than 1.5 seconds.

Figure 2. Test Subject 4, Left Hand Attached to Branch, Left Feed Hopper Position

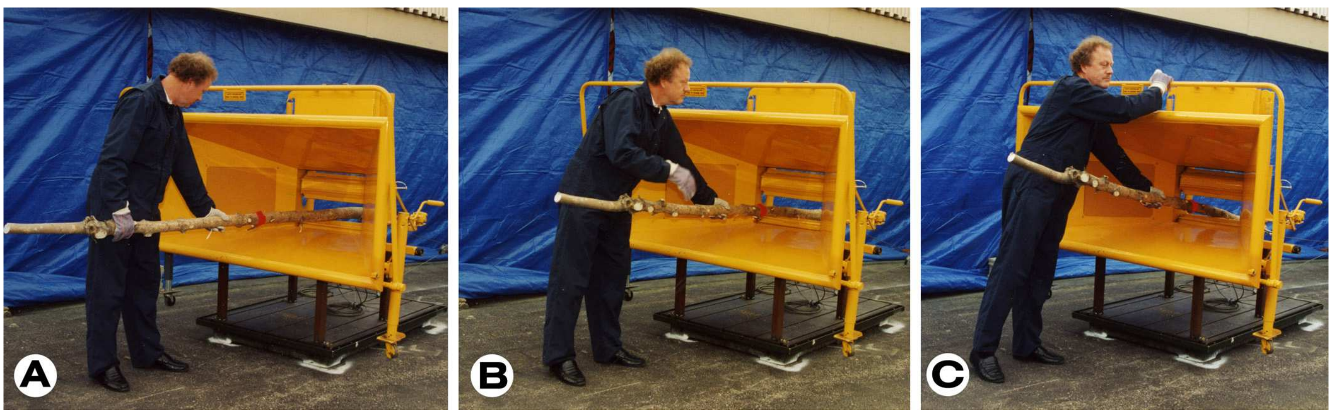

Figure 3. Test Subject 7, Left Hand Attached to Branch, Center Feed Hopper Position

Figure 4. Test Subject 8, Left Hand Attached to Branch, Right Feed Hopper Position

Figure 5. Test Subject 9, Right Hand Attached to Branch, Left Feed Hopper Position

Figure 6. Test Subject 2, Right Hand Attached to Branch, Center Feed Hopper Position

Figure 7. Test Subject 5, Right Hand Attached to Branch, Right Feed Hopper Position

3. CONCLUSIONS

1. Testing using human adult male subjects revealed that their perception-reaction was sufficient to move the safety control bar into the reverse feed wheel position with their free hand before their hand attached to the branch entered the feed wheels during all 60 trials.
2. The perception-reaction time associated with each test trial was considerably less than 1.5 seconds which is consistent with the cited literature.
3. Manufacturers of commercial tree chippers have admonished workers not to place their body parts into the infeed hopper. Similar admonitions are contained in the OSHA Chipper Machine Safety Tips (OSHA, 2005). In addition, ANSI Z133.1-2000 requires that "arborists, workers, and mechanics shall not reach into the infeed hopper when the cutter disc or rotary drum or feed rollers are moving" (ANSI Z133.1-2000). Following warnings and instructions of this type will contribute to reducing tree worker arm injuries.

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