LONG-TERM REPRESENTATIONS IN ABSOLUTE IDENTIFICATION

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Abstract

This paper reports empirical data collected to investigate response biases and practice effects in unidimensional absolute identification. Response biases are manifested by an average error $(R(N)-S(N))$ *that is different from zero when considering all stimuli. Such biases result in shifts of all data points up or down on impulse graphics for sequential dependencies. Individual participant data analysis showed systematic response biases not observed when considering group data. This result provides an additional modeling constraint that might be incompatible with some current models of absolute identification. The data also show that performance in unidimensional absolute identification improves with practice. The results reported here contradict the generally admit postulate that unidimensional absolute identification do no yield stable long-term representations of the stimulus-set.*

Since the publication of the classic paper by Miller (1956), many researchers have extensively studied absolute identification and have produced a large body of results devoted to understanding the puzzling limitation exhibited by humans performing such tasks. While humans are able to identify thousands of complex multidimensional stimuli such as faces or symbols, they do not seem capable of correctly identifying more than seven stimuli varying along a unidimensional continuum.

Despite a large body of empirical and theoretical results, there is yet no consensus on the basic processes involved in absolute judgments. For instance, two sophisticated models recently developed by Stewart, Brown, and Chater (2005) and by Brown, Marley, Donkin and Heathcote (2008) use completely different approaches to model the underlying decision processes. Stewart et al. (2005), in their relative judgment model (RJM), have proposed that participants who absolutely identify unidimensional stimuli are actually making relative judgments. According to the model, the participants would compare the magnitude of a stimulus presented on a given trial with the magnitude of stimuli presented on previous trials. This idea appears consistent with the generally admitted belief that absolute judgments are not prone to learning. Rather than developing stable and accurate long-term representations of the stimulus-set, participants would use sequential information to judge the magnitude of a stimulus. More precisely, these authors have suggested that participants use the relative differences observed across trials in the magnitude of the stimuli, in conjunction with feedback, to determine the appropriate response. This conceptualization is also supported by the observation of strong sequential dependencies in unidimensional absolute judgments. Based on this principle, limited performances in absolute identification are due to limitations in relative judgment processes.

The results reported in the present paper challenge the idea that absolute identification does not yield long-term stable representations of the stimulus-set. New data, analyzed at the individual participant level, revealed response biases not observed when considering group data. This result, which adds an additional empirical constraint in testing theories, suggests that participants performing series of absolute identification trials develop some sort of long-term representations.

As suggested by Lacouture and Marley (2004) and Brown et al. (2008), any useful model of absolute identification should be tested at the individual participant level using both choice probabilities *and* response times. In addition, a comprehensive theory should not only account for average effects but should also explain individual differences. Unfortunately, scant individual data sets provide sufficient data points to perform this kind of analysis and several authors have chosen to test their theories on averaged group data. For instance, Lacouture (1997) provides results for over 11000 trials from 36 naïve participants performing absolute judgments of line length. The average group results have been referenced and used by several authors as benchmark data (e.g., Brown, Marley, & Lacouture, 2007; Lacouture & Marley, 2004; Stewart, et al., 2005). Incidentally, a reanalysis of Lacouture's (1997) data revealed response biases, a key phenomenon that has not been described before and is not currently accounted for by current models. Furthermore, Figure 5 of Lacouture (1997) is inaccurate and should have shown a response bias, even when considering group data.

This paper reports new empirical data that allow individual participant performances to be analyzed using probability correct *and* response time. The first goal of the experiment was to document response biases at the individual participant level. Response biases are manifested by an average error – ordinal position of response minus ordinal position of stimulus on trial N – $(R(N)-S(N))$ that is different from zero when considering all stimuli. Such biases result in shifts of all data points up or down on the impulse graphic for sequential dependencies (see below). The second objective was to document learning effects in unidimensional absolute identification. It is generally believed that unidimensional absolute identification is not prone to learning (for a review see Shiffrin & Nosofsky, 1994). This idea was recently challenged by Rouder, Morey, Cowan, & Pfaltz (2004), who used a modified experimental procedure to demonstrate performance improvement with practice in the absolute identification of line lengths. Although the results by Rouder et al. (2004) seem patent, it has not yet been reproduced. It is also unclear to what extend this practice effect depends on the modified experimental procedure.

In the present experiment, eight participants absolutely identified ten line segments varying in length for *ten* sessions of 300 trials. Contrary to the experiment performed by Rouder et al. (2004), "standard" absolute identification procedures were used. The collapsed group data allowed documenting practice effects. Individual participant data provided enough points to check for response biases.

Method

Apparatus and General Procedure

The experiment was conducted in a dimly lit, sound-attenuated chamber. An MS-DOS-286 computer running Micro Experimental Laboratory software Version 1.0 (MEL; Schneider, 1988) was used for stimulus presentation and response recording. Stimuli were presented within an angular distance of 10° on a BENQ ACL display located approximately 120 cm from the participant. The computer screen was viewed through a 30 cm x 25 cm rectangular opening made using a 1 m x 1 m black cardboard frame. In this setting with the low light in the experimental chamber, the edge of the computer screen could not be easily perceived. Stimulus presentation was synchronized with the vertical retrace of the screen.

Responses were collected using a custom-made keyboard with 11 buttons. The START button was located at the center of the ten other keys, which were positioned in a semi-circle such that the distance between the START button and the response buttons was equal (101 mm). The response keys were approximately 1 cm x 1 cm in size. The technical details of the keyboard are described in Lacouture and Marley (1995) and Lacouture (1997). The keyboard was placed such that participants were able to use their dominant hand. Each response key corresponded to one of the possible stimuli, and the button arrangement corresponded to the natural ordering of the stimuli from the smallest (leftmost key) to the largest (rightmost key). Small labels placed beside each button indicated the corresponding response. Response time – the time elapsed between the onset of the stimulus on the screen and response key press – was recorded and measured in milliseconds using MEL timing routines (Schneider, 1988).

Participants initiated each trial by pressing the START button. One randomly selected stimulus was shown on the screen 100 ms later. They had to identify the stimulus by pressing the appropriate response key. After onset, the stimulus remained on the screen until the participant provided a response.

One second after the response was recorded, feedback was provided for one second in the form of a number corresponding to the ordinal position of the stimulus. If the participant made an incorrect response, a low frequency (500 Hz) tone was generated for 500 ms. A trial ended with the presentation of a blank screen. If the participant waited more than 30 seconds before pressing the START button to begin the next trial, a short sequence of three tones was generated to regain the participant's attention. The same experimental procedure and stimulus-set have been previously used (e.g., Karpuick, Lacouture, and Marley, 1997; Lacouture, 1997; Lacouture and Marley, 1995, 2004;).

Participants

Eight undergraduate university students who had volunteered for the experiment received a monetary compensation of CAN$ 10 for each session for a total of CAN$ 100. All participants reported having normal or corrected to normal vision and no motor handicap.

Design and Stimuli

Each participant completed ten sessions of absolute identification of line lengths. The stimuli were ten line segments presented individually horizontally in the center of the screen. The lengths of each segment, in pixel units (screen dots), were 92, 106, 120, 138, 160, 184, 212, 242, 278, and 320. Adjacent stimuli thus differed by 15% in length (within screen resolution). When Weber’s law holds, which is the case with line length in the range studied in the present experiment, stimuli spaced logarithmically are likely to be equally discriminable and therefore equally spaced along the decision axis. When spaced well above Weber's fraction for line length (2.9% as reported in Teghtsoonian, 1971), the stimuli should also be perfectly discriminable. The line segments were three pixels thick and appeared in white on a black background. From the participant's viewpoint, the stimuli appeared to be continuous lines. The ten stimuli were given “correct” response labels of '1' to '10,' which corresponded to line segments of increasing length. All participants received the standard instructions to “respond as fast and accurately as possible.” The instructions were displayed on the computer screen before each session.

Table 1. Average error (R(N)-S(N)) computed for each participant.

Participant	1	2	3	4	5	6	7	8	All
	-.021	.168	-.079	-.098	-.028	.009	-.018	.027	-.005

Results

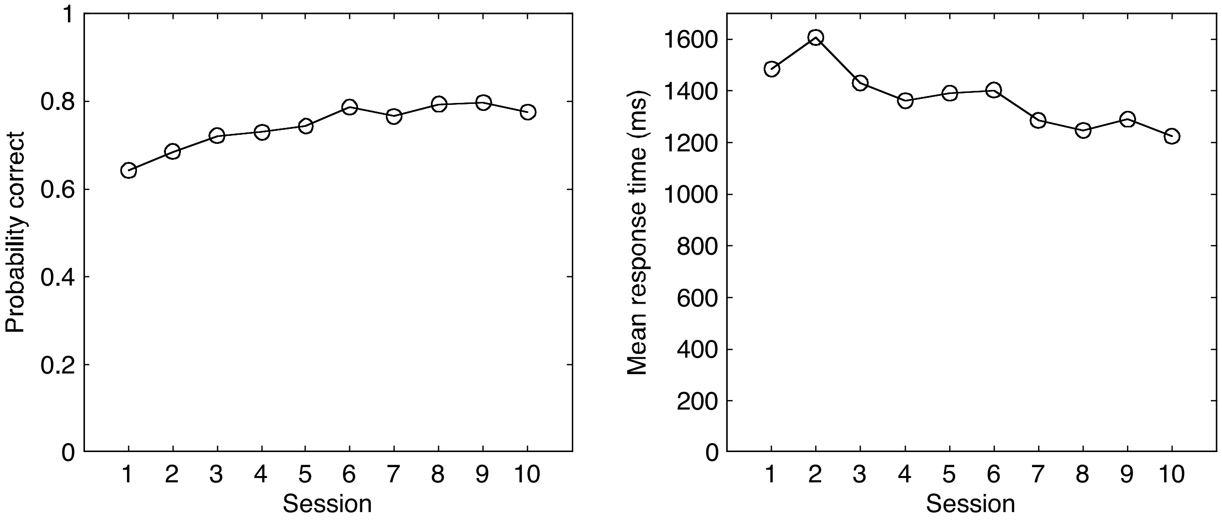

Fig. 1. Practice curves for collapsed data from all participants. The left panel shows probability correct and the right panel presents mean response time plotted according to session number.

Practice effects

Figure 1 shows overall probability correct and mean response time plotted according to session. The results are based on data from all participants. Although perfect performance was not achieved, the data showed a noteworthy practice effect, an increase in overall probability correct with practice, and a decrease in mean response time. This is consistent with the results of Rouder et al. (2004), who observed learning effects on probability correct when three participants performed a 1.5 h session of absolute identification of line lengths every day for seven consecutive days. As with Rouder et al., the improvement in performance did not yield perfect performances. While Rouder et al. did not measure response time, faster response times with practice were observed in the present experiment.

Sequential dependencies and response biases

Table 1 lists the average error (R(N)-S(N)) computed for each participant using all stimuli in all trials. While the overall group error was, on average, close to zero (-.005), some participants exhibited substantial response biases. Figure 2 shows Ward and Lockhead's (1970, 1971) impulse graphics for sequential dependencies drawn using the experimental data. The figure shows the results for each participant (P1 to P8) as well as the averaged results (lower panel). The dotted lines correspond to the average error reported in Table 1. Impulse graphics, proposed by Ward and Lockhead (1970, 1971), are used to analyze accuracy data. This method allows assimilation and contrast effects to be graphed. The average error was plotted simultaneously according to the ordinal position of the stimulus in trial N and the ordinal position of the stimulus in previous trials (N-K). The data was grouped into five ordinal positions (Stimuli 1-2, 3-4, 5-6, 7-8, and 9-10) according to the method used by Ward and Lockhead (1970, 1971). The participants exhibited biases of variable magnitude, some positive and some negative. However, in all cases, the bias caused a shift of all the points on the impulse graphic.

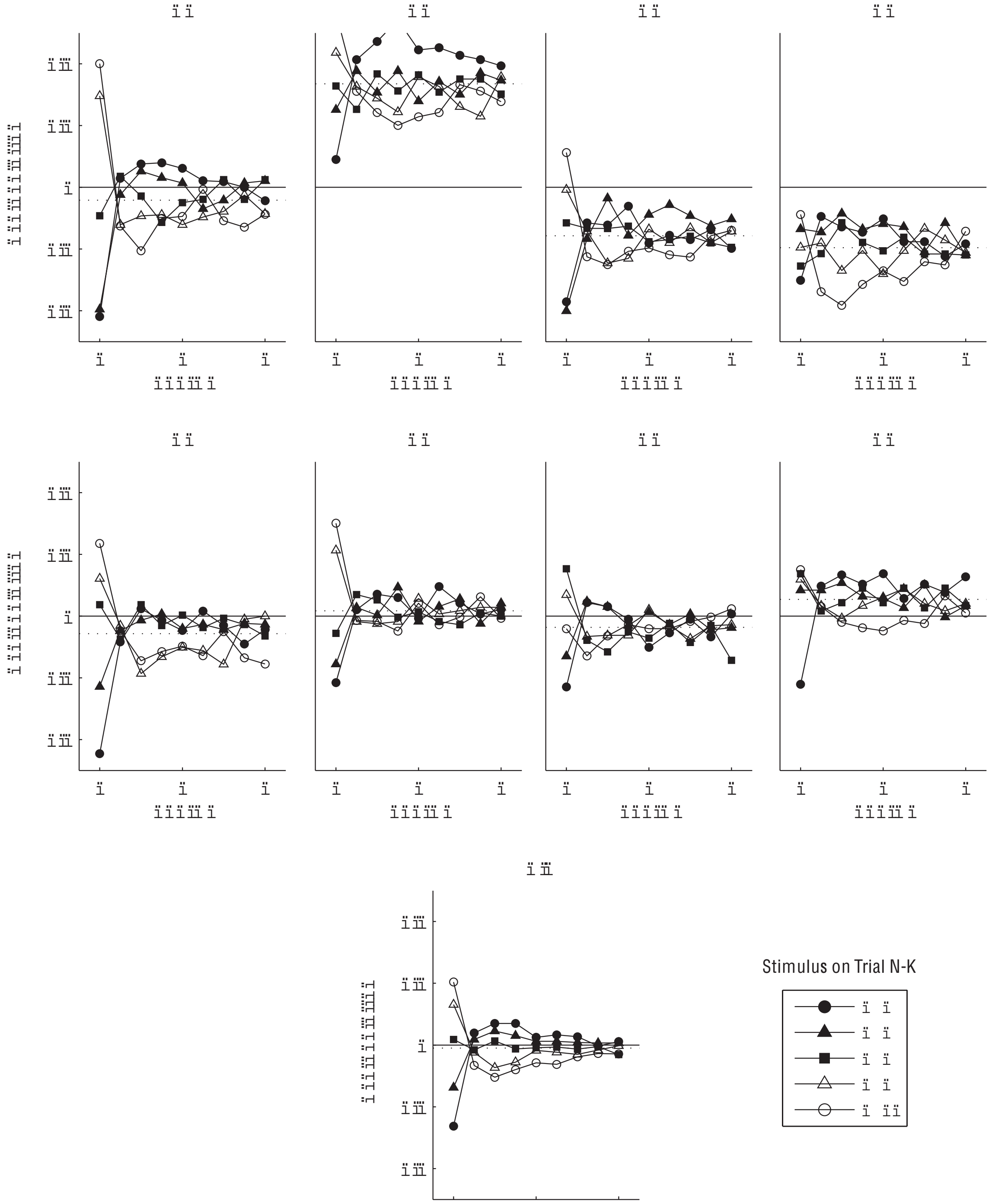

Fig. 2. Ward and Lockhead's graphics for sequential dependencies drown for each participant (P1 to P8). The lower panel shows the average results (all participants). The dotted lines correspond to the average errors reported in Table 1.

Discussion

The present paper reports learning effects in unidimensional absolute identification similar to those discussed by Rouder et al. (2004) and extends previous results by showing effects on response time. Practice effects were obtained using the standard line length absolute identification procedure previously described in several papers. Further analyses at the individual participant level revealed systematic response biases that varied in sign and size across participants. These results are inconsistent with the idea that participants absolutely identifying unidimensional stimuli do not develop stable long-term representations of the stimulus-set.

Acknowledgments

This work was supported by a Natural Sciences and Engineering Research Council of Canada (NSERC) discovery grant.

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