ABSOLUTE PRODUCTION AS A – POSSIBLE – METHOD TO EXTERNALIZE THE PROPERTIES OF CONTEXT DEPENDENT INTERNAL REPRESENTATIONS

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Abstract

Absolute identification requires a participant to identify which stimulus has been presented, from a relatively small pre-specified set – the stimuli might be a set of 9 lines, with the shortest labelled '#1', the longest '#9'. Absolute identification yields many well-established behavioral phenomena - for example, more extreme stimuli (such as lines #1 and #9 in the above example) are identified more accurately, and responded to faster, than more central stimuli (such as lines #4 and #5). Contemporary models propose that the internal representations of the stimuli, and/or of the responses, are context dependent in that they depend on factors such as the number, range, and presentation frequency of the stimuli. We present data on absolute production that we interpret as 'externalizing' the properties of such internal representations and that show effects paralleling those in absolute identification.

Absolute identification involves identifying which stimulus has been shown out of a set of stimuli that vary on only one physical dimension. For example, a participant might be given a set of *n* lines varying in length, or tones varying in intensity, labelled from 1 through to *n*. The participant is then presented with one of these stimuli and asked to recall its label. There are standard results from such experiments (see Stewart et al, 2005) such as a bow effect in mean proportion correct (Figure 1a) and a W-effect in mean proportion correct as a function of the difference in magnitude between the stimulus presented on the current trial and that presented on the previous trial (Figure 2); these data are averaged over participants. Practice increases the magnitude of bow (Rouder et al., 2004). The SAMBA (**s**elective **a**ttention **m**apping **b**allistic **a**ccumulators) model (Brown et al, 2008) successfully models various such data as illustrated by the fits in Figures 1 and 2. Figure 1b) plots the mean standard deviation (SD) of the numerical responses (10 in the present case) and complements the probability correct plot of Figure 1a). We include the SD plot as it has

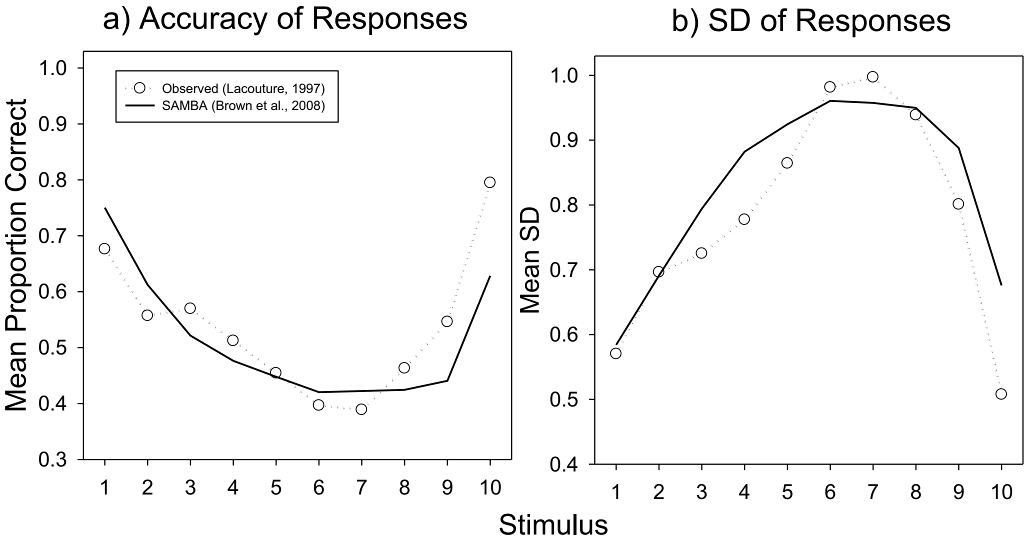

Figure 1. a) Mean proportion correct and b) mean standard deviation in the absolute identification of 10 lines: observed (Lacouture, 1997) and predicted by SAMBA (Brown et al., 2005).

a form that extends naturally to the production data that is the focus of the present paper.

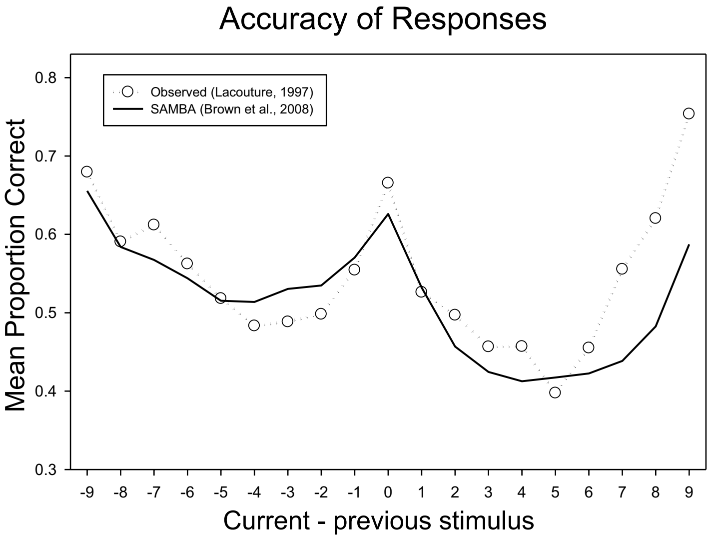

Figure 2. Mean proportion correct as a function of the numerical difference between the current and the previous stimulus (Lacouture, 1997) and predicted by SAMBA (Brown et al., 2008).

In an absolute identification task, cognitive representations and the resulting performance are evaluated by a small number of correct and error responses and by response times (RTs). An alternative approach, which we call *absolute production*, requires a participant to actively create or reproduce a specified stimulus. The motivation of such a task is to obtain more detail on cognitive representations than is provided with a small number of possible responses. Production tasks have been used in studies of semantic categorization (Rosch, 1973), memory distortion (Zangwill, 1937), prototype representation (Busemeyer & Myung, 1988), and magnitude scaling (DeCarlo & Cross, 1990). A production task similar to that reported in this paper was used by Huttenlocher et al. (2000) to study the effects of categories on stimulus judgments and by Zotov et al. (In Press) to study sequential effects in classification. Related work in memory psychophysics concerns context and acquisition effects in the representation of remembered magnitudes (Petrusic et al., 2004). These studies compare Weber fractions in the method of constant stimuli obtained with physical stimuli with those obtained with learned labels; the data show end effects similar to those in absolute identification. The explanations of the Weber fraction effects involve noisy analogue representations of remembered magnitudes, which have larger variability than perceptual stimuli, with the variability dependent on context effects such as the position of stimuli in the presented range. SAMBA has exactly parallel representations that lead naturally to the various bow effects obtained in absolute identification. As stated above, our aim in using absolute production is to obtain more detailed information about these internal representations than is possible in absolute identification - that is, we want, as much as possible, to ‘externalize’ the properties of the representations. Nevertheless, to be a valid method of assessment of performance in AI, the absolute production task should yield results similar to those obtained with standard methods: a bow effect, a W-sequence effect, and practice effect. Moreover, we expect to replicate these effects in “Memory” condition, where participants’ task was to produce stimuli after showing a **label**, but not in “Perceptual” condition, where participants task was to produce stimuli after showing an actual **line**.

Method

Participants. Eighteen Ariel University Center students (ages 19-25 yrs, mean 22.3 yrs) participated in two 1 hour sessions for $10 pay per session. The sessions were approximately one week apart. All participants reported normal or corrected-to-normal vision.

Stimuli and Apparatus. The stimulus set was nine lines, of length 50 to 850 pixels, in 100 pixels (screen dots) increments. The lines were three pixels thick and appeared in black on a white background. The lines were labelled, in increasing length, with the digits 1 to 9. Each digit appeared at the center of the upper third of the monitor. Responses were made using the standard Microsoft mouse.

Design. Each participant took part in two 1 hour sessions, one for a perceptual production task and one for a memory production task. In the perception task, a line was presented for 1sec and, after a blank interval of 200 ms, the participant reproduced it; the procedure in the memory task was the same, except in that condition a number from 1 to 9 was presented and the participant had to produce the associated line. The order of tasks was counter-balanced across subjects. In addition, for each condition (perception, memory), for approximately half of the participants the starting value for each production was a dot, and for the remaining participants it was the correct line length for the previous trial. Thus there were four conditions: memory with dot (MD); memory with previous correct line (MP); perception with dot (PD); and perception with previous correct line (PP).

Prior to each session, participants were shown each line (1-9) along with its label, followed by a short practice block. Each session consisted of 9 blocks of 80 trials. There was a self-terminated break after each block of trials. During the break participants were shown their average accuracy of production and mean response time for the current block and, separately, for all previous blocks. Participants terminated the break by pressing a ‘Continue’ button.

Procedure. After the practice block, participants initiated the first trial by clicking on the ‘start’ button on the screen. A line (in the perceptual task) or digit (in the memory task) was presented 200ms later. The stimulus, either a line or a digit, was presented for 1sec and then the display turned blank for 200ms, followed by the presentation of the starting point (or line) for the trial. In the ‘dot’ condition, the basic line to be adjusted (the ‘starting point’) was a dot. In the ‘previous’ condition, the previous correct response (line length) served as a starting point (except for the first trial in each condition where a dot was presented). Participants adjusted the line length by moving the mouse cursor to the left (decreasing the line length) or right (increasing the line length); technically, the minimal movement is 1 pixel, but practically, it is on the order of 1-3 pixels. When satisfied, participants completed the trial by clicking on the ‘confirm’ button on the screen. Feedback in the form of the exact line to be produced was then presented for 1s and the next trial was initiated 200ms later.

Results

Mean error The mean deviation in all cases was relatively small, relative to the 100 pixel difference in length of adjacent lines, being in the range +/- 10 pixels in the perception conditions and +/- 15 pixels in the memory conditions.

Mean standard deviation Figure 3 shows the mean standard deviation (SD) of production in each condition as a function of the length of the presented line; the mean SD in each condition is the average of the SDs of the participants in that condition.

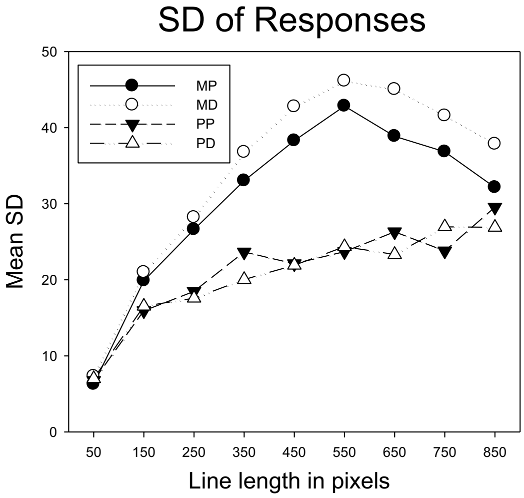

Figure 3. Mean SD in the memory and perception conditions.

An inverse u-shape ('bow') was observed in each memory condition, with a trend analysis confirming a quadratic trend as the most pronounced polynomial trend, $F(1,8) = 147.47$, $p < .0001$ for MP and $F(1,8) = 215.28$, $p < .0001$ for MD. In each perceptual condition, the main significant trend was linear, but the quadratic trend was also significant (accounting for 8-9% of total variance). It is clear that the bow in mean SD is larger in the memory than perceptual conditions as the values for each memory condition are considerably larger than the values for the corresponding perceptual condition. Also, the fact that all four plots of mean SD have approximately the same value at the ends of the range (that is, for the 50 pixel and the 850 pixel line) indicates that the bow is due to some factor that arises in the memory conditions, and not in the perceptual conditions, rather than, say, as a result of increased variability in producing longer lines with the mouse.

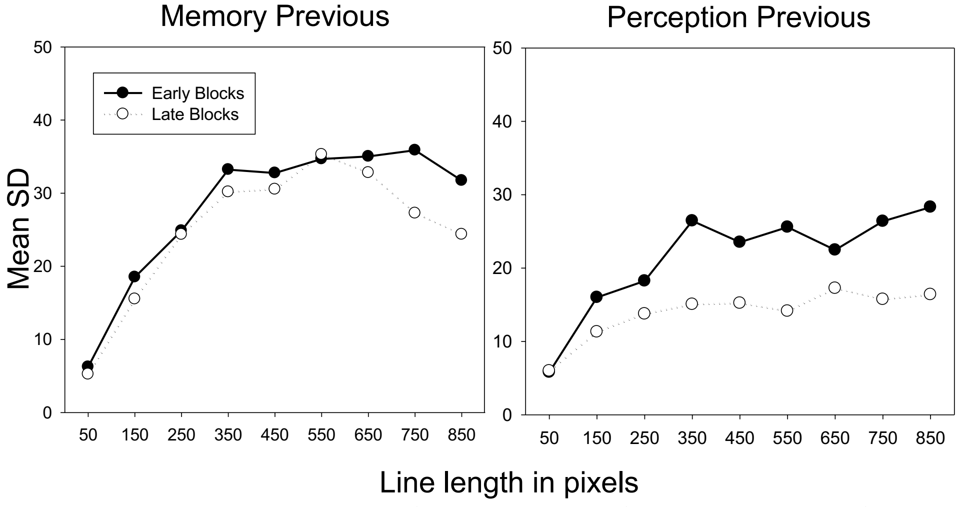

Figure 4. Mean SD for memory and perception conditions for early and late blocks.

Practice Figure 4 shows practice effects in the current data: Early Blocks are the data from first three blocks (84x3 = 244 trials) and Late Blocks are the data from the last three blocks (last 244 trials). Clearly, for both memory conditions the bow effect at the upper end of the range is more pronounced at the later stages; partly (but not entirely) because production is truncated below at zero line length, the SDs at that end are already small in the Early Blocks, confirming the earlier findings of increased bow effect with practice.

Accuracy Another way to summarize production performance is to convert production data into pseudo (absolute) identification data. Thus, productions in the 0-100 pixel range are considered 'correct' for the presented number 1; productions in the 100-200 pixel range are considered 'correct' for the presented number 2; etc. Figure 5 summarizes such average proportions correct in all four conditions. For the 'bounded range', only productions in the 800-900 pixel range are considered correct for number 9, whereas for the 'unbounded range', all productions above 800 pixels are considered correct for that number; the latter calculation reflects the corresponding calculation in absolute identification where no response greater than 9 can occur. Each memory condition produces a 'classical' (absolute identification) bow shape, whereas each perception condition shows only decreased accuracy as a function of line length.

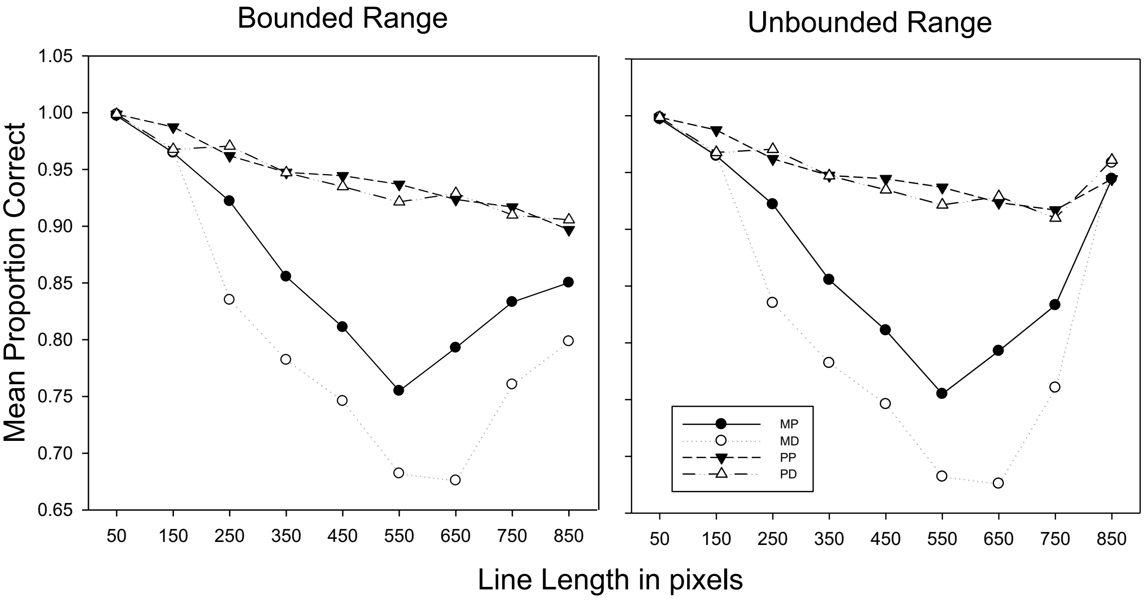

Figure 5. Mean proportion correct derived from the production data.

Sequence effects Figure 6 shows sequence effects in a 'Rouder plot' (Brown et al, 2008). This plots mean proportion correct, as a function of the difference between the correct line length on the current trial and that on the previous trial; the mean proportions correct are derived from the production data as in the 'unbounded range' case of Figure 5. There are advantages for both small and large differences between consecutive stimuli in each memory condition (as in classical absolute identification data), while there is no such advantage for either perception condition.

Discussion

The memory production data, when plotted in ways paralleling those used for absolute identification data, produce accuracy, sequential, and learning effects similar to those in the latter task; such effects do not exist in the perceptual (re)production data, which suggests that only the memory production data involve the same mechanisms as those in standard methods of assessment in AI task. It is early to say why the perception production did not yield the same results as memory production task; one possible explanation is that, similar to Petrusic et al. findings (2004), only memory condition involves noisy representations of remembered magnitudes with the variability dependent on the position of stimuli in the presented range. This suggests that an extension of an absolute identification model such as SAMBA may be fit to the full produced line distributions in the memory production task, thus providing additional tests of the properties of SAMBA's internal representations. Preliminary extensions of SAMBA by Scott Brown (Newcastle) support this perspective.

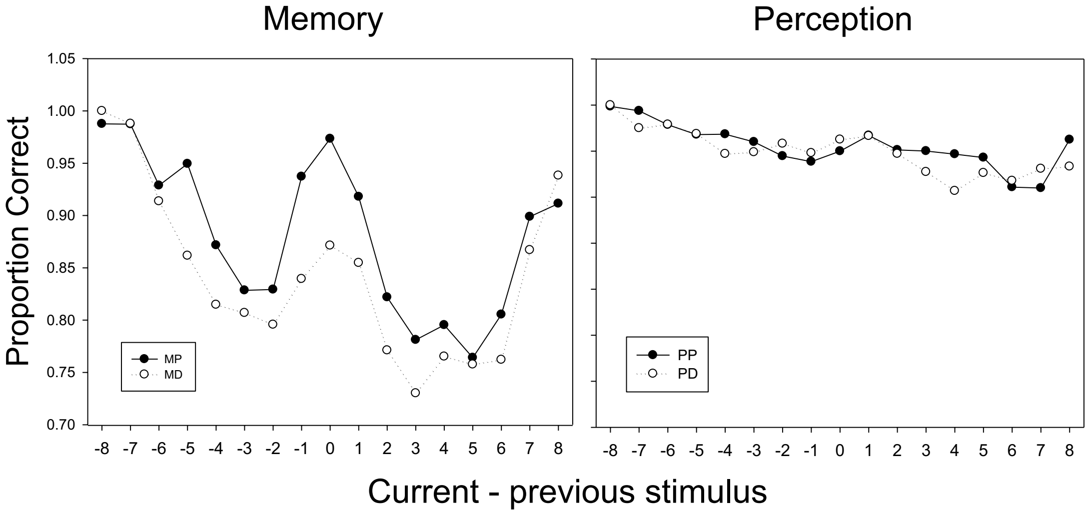

Figure 6. Mean proportion correct as a function of the numerical difference between the current and preceding correct line.

Acknowledgements

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