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Using Vocal Production to Improve Long-Term Verbal Memory in Adults with Intellectual Disability

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Abstract

Individuals with intellectual disability (ID) typically show weak long-term memory (LTM) skills. Understanding verbal LTM processes and searching for effective mnemonics in this population is important, to improve intervention programs. The current study aimed to assess verbal LTM abilities of adults with mild ID of mixed etiologies, and to offer a simple memorization technique based on vocal production. Participants ($n = 55$) learned lists of different study materials (images of familiar and unfamiliar objects, written words, and sentences) by vocal production (saying or reading aloud) or by no-production (looking, listening, or reading silently). Memory tests followed. Better memory was found for vocally produced images of familiar objects, written words, and sentences. The results show that adults with mild ID can benefit from the relative distinctiveness of items at study. Hence, vocalization may be used in educational and therapeutic contexts for this population, improving memory performance.

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Intellectual disability (ID) is a developmental disability that originates before the age of 18 years, is characterized by below-average intellectual functioning, and by limitations in adaptive behaviors (e.g., social and practical skills necessary for daily living; Schalock et al., 2010). ID affects about 2–3% of the general population (Daily et al., 2000). The level of cognitive impairment ranges in severity for each person, from mild to moderate intellectual impairment (IQ scores of between 40 and 60), to severe cognitive impairment (IQ < 40). Some individuals with ID are diagnosed with specific syndromes (syndromic ID, e.g., Down syndrome, fragile X syndrome), while others do not (non-syndromic or idiopathic ID). In this latter group, intellectual deficits may appear without other medical and behavioral signs and symptoms, or with associated developmental disabilities that reflect central nervous system compromise (Evenhuis et al., 2001).

Individuals with ID often demonstrate related physical disabilities, such as vision problems, hearing impairments, seizure disorder, and cerebral palsy (Harris, 2006; Owens et al., 2006). By definition, ID involves cognitive deficits. One of the most investigated cognitive domains in people with ID is memory (Vicari et al., 2016), which is the focus of the current study.

Memory Impairments among Individuals with ID

Efficient memory functions are crucial to the development of cognitive and functional skills, allowing individuals to store, manipulate, and retrieve relevant information (Edgin et al., 2010). Numerous studies have documented memory impairments among individuals with ID (e.g., Lifshitz et al., 2011). Interestingly, these deficits are not homogeneous, but related to the specific etiology of ID. In other words, differential patterns of memory abilities are observed across different etiological groups of individuals with ID (Vicari et al., 2016).

For example, individuals with Down syndrome typically show deficits in the explicit domain of long-term memory (LTM, which deals with consciously remembering facts and events) compared to the implicit domain (which one uses unconsciously), which was found to be relatively preserved (Carlesimo et al., 1997). This group also shows verbal and spatial short-term/working memory deficits (Lanfranchi et al., 2009; Vicari et al., 1995). Studies on Williams syndrome resulted in somewhat mixed results. These individuals were found to show relatively poor performance on tests of LTM for visual information (Jarrold et al., 2007) and weakness in visuospatial short-term memory, along with strengths in auditory rote memory (Mervis & Klein-Tasman, 2000). Individuals with fragile X syndrome demonstrate working memory deficits, especially in tasks that require high levels of control (Lanfranchi et al., 2009; Munir et al., 2000). In a related meta-analysis, Lifshitz et al., (2011) also found evidence regarding patterns of cognitive functioning that differ in qualitative terms, amongst the various etiologies to the implicit memory domain.

To recap, the literature suggests that people with ID have different patterns of relative strengths and weaknesses on memory measures (Edgin et al., 2010). In addition, their ability to use memory strategies is limited (Levén et al., 2008), and they show restricted benefits from strategies such as rehearsal (using repeated practice of information to learn it) and imagery (developing visual imagery and associating images with each other; for a literature review, see: Poloczek et al., 2016).

Identifying and understanding LTM processes in the ID population is of importance, as LTM provides the lasting retention of information and skills. Since LTM holds large amount of information and can last for a very long time, it is essential for everyday functioning and learning. Hence, finding effective strategies to improve verbal LTM functioning within this group is essential to better design intervention programs. The current study aimed to assess verbal memory abilities and to offer a simple memorization technique using the Production Effect (PE).

The Production Effect (PE) in Memory

The production effect (PE) is a well-known LTM phenomenon, and refers to an enhanced memory for items read aloud (vocalized) relative to items read silently at study (Forrin et al., 2012; MacLeod et al., 2010; Mama & Icht, 2016b). In a typical PE experiment, participants learn a list of words, half by vocal production and half by silent reading. In a later memory test (recall or recognition), aloud words (that were vocally produced) outperform silent words—a PE.

The PE has received much research attention over the last decade. It has been confirmed with a variety of study materials (e.g., images: Icht & Mama, 2015; nonwords: MacLeod et al., 2010; text: Ozubko et al., 2012), and across several populations (e.g., pre-school children: Icht & Mama, 2015; dysarthric adults: Icht et al., 2019; hearing impaired adults: Taitelbaum-Swead et al., 2017, 2018; adults with ADHD: Mama & Icht, 2019). Thus, it was offered as a simple and effective mnemonic device (Ozubko et al., 2012).

The PE is commonly attributed to encoding distinctiveness (MacLeod et al., 2010). According to this account, producing items at study increases their distinctiveness in memory relative to unproduced items. At test, this distinctiveness facilitates access to aloud items, increasing their memory rates relative to silent items. Alternatively, the PE may be the result of increased attention to the produced items (MacDonald & MacLeod, 1998; Mama et al., 2018; Ozubko et al., 2012). At study, participants pay more attention to words that are read aloud relative to silent words. The high attention levels result in better memory performance.

The Current Study

The current study evaluated verbal LTM abilities in a heterogeneous group of adults with mild ID, using a Production Effect (PE) paradigm. Participants performed four experimental tasks, learning lists of (a) familiar images, (b) unfamiliar (rare) images, (c) familiar written words, and (d) short written text (sentences). Half of each study list was studied by vocal production (saying aloud) and the remaining half by no-production (looking at the picture, listening to the experimenter, or reading silently). Memory tests followed.

Considering the existing PE literature, that demonstrates production benefits across various populations and study materials, we expected to find a memory advantage for vocally produced items relative to non-produced items, a PE. Comparing memory performance between the two learning conditions (no/ production) will enable us to better understand LTM processes in this population, and asses the size of the production benefits. Currently, it is not clear whether adults with ID can benefit from encoding distinctiveness (for a discussion on the influence of cue distinctiveness, see McDaniel & Einstein, 1993). The current results will shed light on this theoretical issue. Clinically, if there is a significant memory advantage for vocalization, it will support the ability to use this simple method to improve memory and learning for adults with ID.

Experiment 1—Images

This study was approved by the institutional Ethics Committee. Potential participants and their parents or legal representatives received written and oral information on the study, after which their written consent was obtained. All participants gave their oral consent. Following this, the participants were invited to attend one or two experimental meetings. They received a gift-card of the equivalent of 25 USD for participation.

In Experiment 1, the participants learned lists of images, familiar (Experiment 1A) or unfamiliar (Experiment 1B), in a PE procedure. Both Experiments were conducted in a single experimental session (in a counter-balanced order across participants).

Experiment 1A—Images of Familiar Objects

Method

Participants. Fifty-five adults with ID (26 men and 29 women; age range: 20–45 years; mean age: 29.5 years) participated. All had mild ID requiring minimal supervision for daily activities. The participants were recruited from social services departments, all live in out-of-home frameworks and work in daycare centers in the center of Israel. All participants were native Hebrew speakers, and none had secondary conditions or complications (such as visual or hearing), that could have made it difficult to perform the experimental tasks. As to ID etiologies, 6 of the 55 participants had Prader-Willi syndrome, two participants had Down syndrome, and, in the remaining cases, the cause of the ID was unknown.

Inclusion was based on the following criteria: (a) level of speech production—the Social Worker of the daycare center identified all participants as verbal, that is, their main modality of communication was their natural speech, (b) level of intelligibility—two research assistants, speech-language pathology students, confirmed that the participants were partially or fully intelligible, and (c) level of literacy—all participants were identified with at least word-level reading skills and performed a reading screening test (the full procedure is detailed below). The main exclusion criterion was the presence of severe behavioral problems.

Apparatus and stimuli

Study material—images of familiar objects. The pool of items consisted of colored pictures of sixty familiar objects (taken from Icht & Mama, 2015, Exp. 1), all di-syllabic nouns (e.g., "orange," "boat," "closet"; see Figure 1, Panel A). From this pool, thirty pictures were selected for study, a different random sample for each participant, and the remaining thirty pictures were used as distractors in a memory recognition test. The thirty study pictures were randomly divided into two subsets of fifteen pictures (a different allocation for each participant) and defined by the learning condition: "look" (no-production condition) or "look and say" (production condition).

During the study phase, each picture was presented singly for view under the control of the DirectRT program. The picture size was about

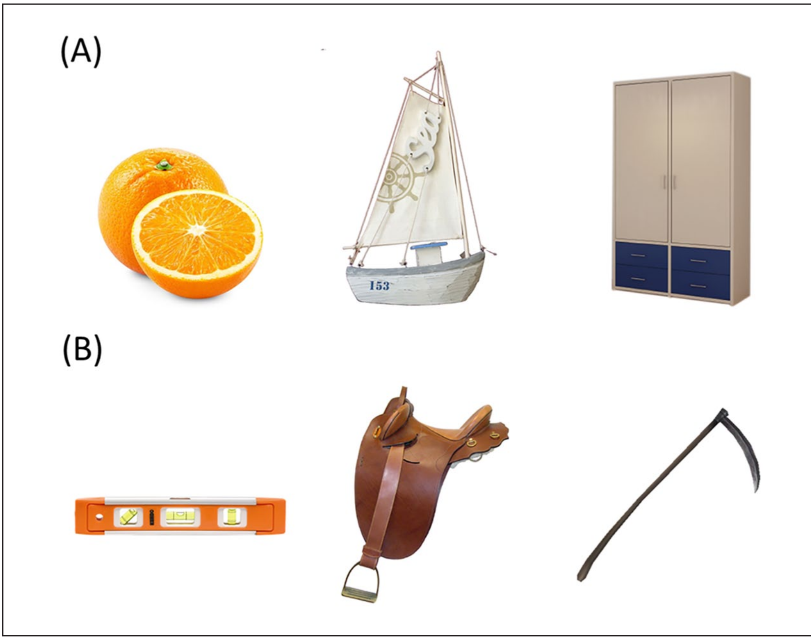

Figure 1. Examples of the study material: (A) images of familiar objects, and (B) images of unfamiliar (rare) objects.

4 cm^2, and they appeared at the center of a 15-inch color monitor (Compaq laptop computer) against a white background. On each trial, a small symbol (2 cm^2) appeared 2 cm above the study picture. The symbol indicated the appropriate learning condition for that item; a mouth (lips) with an X mark on it indicated the no-production condition and a mouth indicated the production condition. Note, we used these symbols across all experimental tasks (regardless of the study material) to avoid confusion and reduce the likelihood of participant errors.

Memory test—yes/no recognition test. Yes/No recognition test was conducted following the study phase. A total of 60 items were presented (15 produced items from study, 15 non-produced items from study, and 30 new un-studied items from the original pool). These items were visually presented one at a time in a random order (under the control of the DirectRT program). Items remained visible at the center of the screen until the participant responded verbally. A research assistant coded participant responses.

Design and procedure. The participants were tested individually in a quiet room in their Supported Employment center. Two experimenters (research assistants, speech-language pathology students) were present throughout the session to ensure that they performed the tasks properly. Then, participants were given a short explanation regarding the experiment and the different tasks. They were seated facing the center of the computer screen (at a distance of about 60 cm). Participants were shown the instruction symbols and were asked to say words aloud when the mouth symbol appears, but to avoid vocalizing when the "deleted" mouth symbol appears. A short practice block of four images followed. They were told that their memory would be tested following each study phase, but they were not told the exact nature of the test.

Study phase. Each study trial began with the study image in the center of the screen and the instruction symbol above it for 4 sec. Following this, a blank screen was displayed for 1 sec, and then the next study item appeared.

Test phase. Immediately following the study phase, participants were given instructions for the Yes/No recognition test. One of the experimenters sat next to the participant, both viewing the computer screen. The experimenter controlled the test presentation by pressing the spacebar. The other experimenter coded the participant verbal responses (saying yes or no). The whole Experiment lasted about 25 min.

Results

The results of six participants were excluded due to high false-alarm rate (>33.3%), thus the analysis included 49 participants. The left hand-part of Figure 2 gives the results of the recognition test. Plotted are the proportions of correct responses for the two learning conditions, vocal production and no-production. Visual inspection reveals the advantage of vocal production over no-production for images of familiar objects, a PE. A paired-sample *t*-test (single tailed) confirmed this result, $t_{(48)} = 6.189, p < .001$.

Experiment 1B—Images of Unfamiliar Objects

Method

The method of Experiment 1B closely followed that of Experiment 1A, with two exceptions: (1) Stimuli—in this experiment, images of rare, unfamiliar words were studied and (2) Memory test—a four alternative forced choice (4AFC) test was used, in order to asses associative verbal learning (word-image) rather than visual memory.

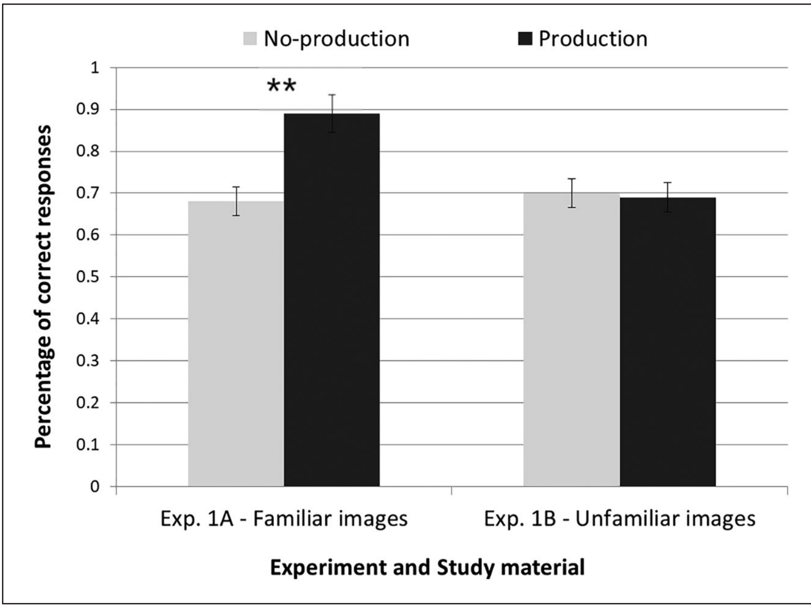

Figure 2. Proportions of correct responses for the subsets of produced and non-produced items, for experiment 1A (familiar images) and 1B (unfamiliar images). The error bars are standard errors of their respective means. The asterisks represent a significant difference, $p < .01$.

Participants. Fifty participants took part in the current experiment, from the same group of 55 adults with mild ID who participated in Experiment 1A (five participants were unable to perform the memory test and were excluded).

Apparatus and stimuli

Study material—images of unfamiliar objects. The item pool consisted of colored pictures of sixty rare words (taken from Icht & Mama, 2015, Exp. 2), all di-syllabic nouns (e.g., "leveler," "saddle," "sickle"; see Figure 1, Panel B). From this pool, thirty pictures were selected for study (a different random sample for each participant), and the remaining thirty pictures were used as distractors in the memory test. The thirty study pictures were randomly divided into two equal subsets (a different assignment for each participant), defined by the learning condition: "look and listen" (no-production condition) or "look and say" (production condition).

At study, each of the study words appeared with the small symbol, indicating its learning mode; a mouth with an X mark on it indicated the no-production condition, in which the experimenter said the word aloud twice. A mouth symbol indicated the "look and say" condition, in which the experimenter said the word aloud once, and the participant vocally repeated it. We chose this procedure to obtain an equal number of auditory exposures of the study words across the learning conditions (i.e., each study word was heard twice, either only by the experimenter or by both the experimenter and the participant).

Memory test—a four-alternative-forced-choice (4AFC) test. The study phase was followed by a 4AFC test. The participants were presented with 30 picture slides (under the control of the DirectRT program). On each slide, four different pictures appeared, the target image (from study) and another three distractors (one that was learned by the same learning condition as the target image, another learned by the other learning condition, and a new image not presented at study). The order of the slides and the arrangement of the pictures were different for each participant. As a slide appeared, the experimenter said the target word aloud and the participant had to point at the appropriate picture. The experimenter marked participant responses on a designated form, and then the next slide appeared.

Design and procedure. These were similar to Experiment 1A.

Results

The right hand-part of Figure 2 gives the results of Experiment 1B, with the proportions of correct responses for the two learning conditions (vocal production and no-production). Note, since a 4AFC test was used, the chance-level was 25%, simply by guessing correctly. Yet, the scores were well above the chance level (using one-sample t-tests, both $p < .0001$). Observing Figure 2 reveals the lack of a PE for this experiment, as recognition rates were similar for vocal production and no-production conditions, $t_{(49)} = 0.356$, $p = .361$.

Error analysis. To analyze the error pattern (words incorrectly recognized), we calculated error rates for the various response classifications (type of distractors): same learning condition as the target image, different learning condition, and new images not presented at study. A repeated measures ANOVA revealed a significant effect, $F(2,98) = 12.252$, $p < .001$, $\eta_p^2 = 0.2$. Contrast analyses revealed that most of the errors (80%) were of images that were previously studied [produced or non-produced, which did not significantly differ, $F(1,49) = 0.912$, $p = .34$, $\eta_p^2 = 0.018$]. Only a smaller portion of errors (about

20%) was of new images, which did not appear at study, $F(1,49)=20.797$, $p<.001$, $\eta_p^2=0.298$ (contrasting old and new images).

Discussion

In this pair of PE experiments, the participants learned different study lists of familiar images (Experiment 1A) or unfamiliar images (Experiment 1B). Half of the study items were learned by vocal production and the remaining half by no-production. As expected, a PE was documented for familiar images. Surprisingly, no PE was documented within the list of unfamiliar, rare images.

The results of the familiar images task demonstrate that individuals with ID benefited from vocal production, as recognition rates were superior in the "look and say" condition relative to the "look" condition. Equivalent results have been previously observed in a group of pre-school children (using a free recall task; Icht & Mama, 2015, Experiment 1). From a theoretical perspective, the presence of the PE suggests that individuals with ID can use distinctiveness heuristics to improve memory performance. We assume that studying an image by vocal production ("look and say" condition) creates a distinctive memory representation relative to studying an image by no-production ("look" condition). At test, participants successfully gain access to the detailed pictorial and verbal information in order to support a positive recognition decision, leading to high recognition rates for the produced items. Failure to gain access to such distinctive information tend to result in a negative recognition decision, resulting in lower recognition rates for the non-produced items. This pattern of results likely reflects the operation of a distinctiveness heuristic - a mode of responding based on participants' metamemorial awareness that true recognition of studied items should include recollection of distinctive details (Johnson et al., 1993; Schacter et al., 1999). The current PE in the group of individuals with ID provides an initial support for their ability to use a distinctiveness heuristic.

From the clinical perspective, the PE for familiar images shows that vocal production can significantly enhance the verbal memory performance of adults with ID. It can be easily used in everyday life situations as well as in therapeutic or educational contexts. For example, in many rehabilitative settings (e.g., daycare or therapeutic centers), the routine daily tasks, academic protocols, and leisure activities are visually presented on visual boards (visual activity schedules, VAS). The sequence of visual cues provides the learners with a stimulus prompt to follow a series of activities or tasks independently (Spriggs et al., 2017). Saying aloud these visual cues may help remembering them, allowing higher levels of independence and smooth transitions between and within activities.

Note the recognition rates were fairly high for both types of words, produced and non-produced (89% and 68%, respectively). This finding is in line with a research review reporting intact recognition abilities for individuals with nonspecific ID (Lifshitz-Vahav & Vakil, 2014). This may imply that studying visual images (pictures) is particularly suitable for this population, as has been previously reported in various studies (Mechling, 2007). Visual supports may provide aids to maintain attention, understand spoken language, sequence of events (e.g., VAS), and increase independent task performance (Hodgdon, 1995).

The other interesting finding of Experiment 1 was a lack of a PE for studying images of rare, unfamiliar objects. The procedure of this experimental task closely followed that of a previous study with pre-school children with typical development (TD; Icht & Mama, 2015, Experiment 2). In this former study, a significant production benefit was obtained for produced unfamiliar words ("look and say" condition) relative to non-produced rare words ("look and listen" condition). Similarly, a PE was found for nonwords (MacLeod et al., 2010) as well as for unfamiliar L2 words (Icht & Mama, 2019, In Press) in TD students. Thus, the absence of a PE in the current study was somewhat surprising.

Attempting to explain this finding, one should note that a rare or unfamiliar word is lacking stored phonological representation in the mental lexicon (like a nonword; Icht, & Ben-David, 2015). Hence, participants need to have a more complete phonological specification of the novel sound pattern to be able to recognize it in response to the visual cue (image) presented at test (Gathercole et al., 1997). Since the capacity of the phonological loop component of the working memory of individuals with ID is constrained (Numminen et al., 2002), their ability to retain unfamiliar phonological sequences is reduced, and it seems that a single vocal production is insufficient to improve memory. Interestingly, inducing familiarity with nonwords by having participants repeat them aloud has been found to result in improvements in memory span for those items, possibly due to the acquired knowledge of their phonological forms (Hulme et al., 1995). Yet, this pattern was noted in individuals of TD, and may be different (less efficient) for people with ID.

Another related memory phenomenon, the *generation effect*, is interesting to consider because it may offer an alternative explanation for the lack of a PE for rare or unfamiliar images, based on lexical and semantic deficits rather than poor phonological memory. The generation effect refers to better memory for self-generated words (that are learned in an active, effortful manner) than for words that are externally presented (thus learned by merely passive reception; Slamecka & Graf, 1978). Although this effect has proved to be remarkably robust, it is not found when the response terms are nonwords or unfamiliar words that do not correspond to familiar concepts in LTM (Hirshman & Bjork, 1988). Presumably, this finding indicates that the activation of specific, preexisting item features (e.g., lexical characteristics of the word as a whole unit, semantic knowledge and verbal information about the referent) is necessary for the generation effect to occur (McElroy & Slamecka, 1982). In other words, in order for the act of generation to enhance retention, participants must be able to access a preexisting lexical address during the generation process. The same rationale may explain the current results—no PE for unfamiliar words for adults with ID. Adults with ID tend to have an inadequate exposure to basic vocabulary terms thus their lexical and semantic knowledge is limited (Hua et al., 2013). The lack of preexisting item knowledge, and in particular, words and their corresponding definitions, leads to the absence of a production benefit. Presumably, in order to show a production benefit for unfamiliar words, adults with ID should have a deeper and more complete understanding of vocabularies, other than simple word-image associations.

Experiment 2—Written Material

In Experiment 2, the participants learned lists of written material, words (Experiment 2A) or text (sentences, Experiment 2B), in a PE procedure. To select the participants for these experiments, a reading screening test was conducted at the end of the first experimental session (as will be described next). Participants who passed this test were invited to another experimental session in the following week. Both Experiments 2A and 2B were conducted in this second session, in a counterbalanced order.

Experiment 2A—Written Words

Method

Participants. Thirty-five participants took part in the current experiment, from the same group of 55 adults with mild ID who participated in Experiment 1A. All participants passed a reading screening test confirming their reading level.

Apparatus and stimuli

Reading screening test. To determine participant reading level, a reading screening test was administered (two reading comprehension tasks from the

Reading and Writing Test in First Grade, National Institute for Testing and Evaluation, Ministry of Education). Based on their satisfactory performance on this screening test, 35 participants were selected to perform the written tasks (Experiment 2A—words, and Experiment 2B—sentences) in addition to the images tasks that were performed the week before.

Study material—written words. The stimuli were 60 common Hebrew di-syllabic nouns (from Icht et al., 2014). From this pool, a random sample of 30 words was selected for study for each participant, with the remaining thirty words used as distractors in a memory recognition test. The thirty study words were randomly divided into two equal subsets (a different allocation for each participant), defined by the learning condition: "read silently" (no-production condition) or "read aloud" (production condition).

At study, each written word was visually presented at the center of the laptop computer screen. The DirectRT program controlled the presentation. The words appeared in 28-point sized black David font against a white background. Each of the study words appeared with the small symbol, representing the appropriate learning mode; a mouth with an X mark on it indicated the no-production condition, while a mouth indicated the production condition.

Memory test—yes/no recognition test. This test was similar to the one used in Experiment 1A, except that written words were presented.

Design and procedure. These were similar to Experiment 1A.

Results

The results of six participants were excluded, due to high false-alarm rate ($>$33.3%), thus the analysis included 29 participants. The left hand-part of Figure 3 gives the results of Experiment 2A, with the proportions of correct responses for the two learning conditions - vocal production (reading aloud), and no-production (reading silently). Figure 3 clearly shows a PE for learning written words, with higher recognition rates for vocal production relative to no-production conditions, $t_{(28)} = 5.648$, $p < .001$.

Experiment 2B—Written Text

Method

The method of Experiment 2B followed a former experiment that used text as the study material (Ozubko et al., 2012, Experiment 3).

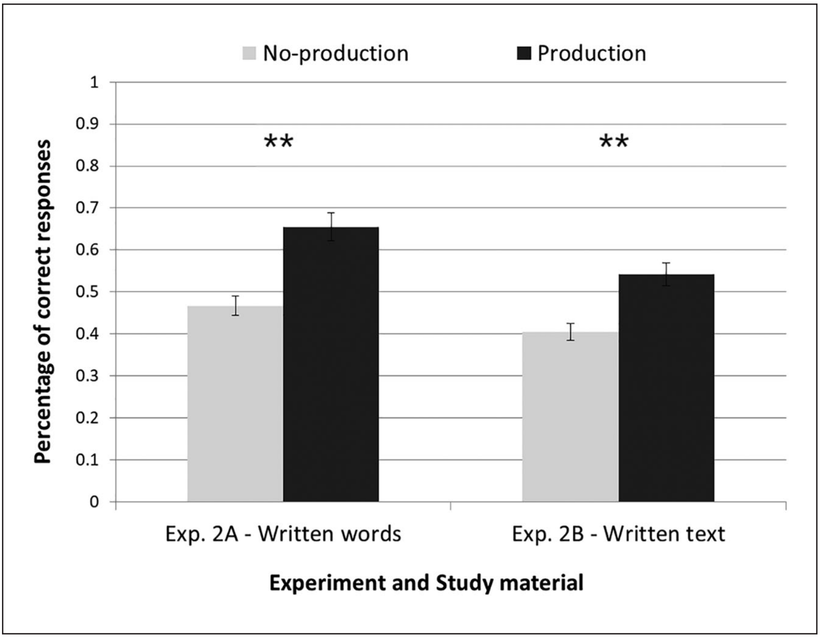

Figure 3. Proportions of correct responses for the subsets of produced and non-produced items, for the experiment 2A (written words) and 2B (written text). The error bars are standard errors of their respective means. The asterisks represent a significant difference, $p < .01$.

Participants. Of the group of 35 adults with mild ID who performed Experiment 2A, 31 participated (four participants were unable to complete the experimental task and were excluded).

Apparatus and stimuli

Study material—written text (sentences). We created a short paragraph, consisting of a series of ten related sentences (eight to twelve words each, a total of 94 words). The paragraph was designed to be relevant in content to the participants (it dealt with a visit by two friends to the mall). The study paragraph was printed on an A4 page, in 16-point sized black David font. Half of the sentences were randomly assigned to be presented on a light grey background and half on a dark grey background. These grey backgrounds were used to identify whether the sentences were to be read aloud or silently during study. The learning modes corresponding to the background colors were counterbalanced across participants.

Memory test—oral test. Following the completion of the study phase of the text task, an oral test of ten questions was conducted (each question referred to a single sentence from the study text). The questions were read aloud by one of the experimenters, while another wrote down participant answers. To score the tests, participants were awarded two points for a correct and full answer, one point for a partly correct answer, or 0 for incorrect or no answer.

Design and procedure. Before this experimental task, the participants received an explanation regarding its nature (that was different from the other tasks, as it was not conducted via computer but using a printed text, with background colors indicating the mode of production rather the mouth symbols).

For study, participants were given the printed paragraph, and were instructed to read the sentences with light backgrounds aloud and those with dark backgrounds silently; the other half of the participants had this assignment reversed.

For the oral test, one of the experimenters read aloud the questions, while the other wrote participant answers. There was no time limitation for the memory tests.

Results

The right hand-part of Figure 3 gives the results of Experiment 2B. Plotted are the proportions of correct responses for the two learning conditions—vocal production (reading aloud), and no-production (reading silently). Observing Figure 3 reveals a PE for learning written text, with higher scores for questions that probed information that had been vocally produced relative to information that had not been produced, $t_{(30)} = 2.915$, $p < .01$.

Discussion

The current Experiment revealed the advantage of vocal production for studying written material for adults with ID. In Experiment 2A, studying a list of written familiar words, a PE occurred. Namely, words that were read aloud at study were better recognized at test relative to words that were read silently. This finding is the "classic" and familiar PE, depicting the memory advantage for vocally produced written words over silent words (e.g., Forrin et al., 2012; MacLeod et al., 2010). The presence of a PE confirms that adults with ID can successfully use distinctiveness at encoding to enhance verbal memory.

In Experiment 2B, the advantage of vocal production was also found for written text, as memory was better for questions that probed information that had been read aloud relative to information that had been read silently (for similar results with undergraduates, see Ozubko et al., 2012, Experiment 3). Additionally, the production benefit was observed on an educationally relevant test—an oral exam. As many academic situations involve studying written text (Chan et al., 2006), this finding is of clinical importance. As noted by Ozubko et al. (2012), “It is difficult to imagine a simpler technique for improving retention during studying” (p. 726). The current results are in line with this notion, extending the usage of vocalization to the ID population.

Combined Results for Experiments 1A and 2A

Experiments 1A and 2A were comparable in terms of design and procedure. In Experiment 1A, participants learned a list of familiar images (objects) and in Experiment 2A, they studied a list of familiar written words (object names). In addition, in both experiments, a Yes/No recognition test was used. It allowed us to directly compare both experiments, using a repeated measures ANOVA, with study material (×2; images, words) and learning condition (×2; production, no-production) as within subject variables. This analysis yielded a main effect for study material, with better recognition rates for images than written words, $F(1,28)=30.343$, $p<.001$, $\eta_p^2=0.520$, and a main effect for learning condition, with an advantage for vocal production over no-production, $F(1,28)=46.864$, $p<.001$, $\eta_p^2=0.626$. No interaction was found for these variables, $F(1,28)=3.121$, $p=.088$, $\eta_p^2=0.1$.

This pattern of results stresses the benefit of studying visual images for the population of adults with ID (Hodgdon, 1995; Mechling, 2007). Using visual illustrations by special educators (in books as well as classroom aids) and by therapists (within therapy sessions), seems promising in enhancing LTM performance (for related results, see Poloczek et al., 2016). The combined effect of studying images by vocal production (saying aloud) results in superior memory performance.

General Discussion

Many everyday-life activities depend on remembering things for long periods of time and retrieving them when needed, like names, addresses, appropriate routes to and from work, and so forth. The term LTM refers to such information, that has been stored and that is available over an extended period of time. Adults with ID often have LTM difficulties that may contribute to their learning problems and overall cognitive impairments (Vicari, 2004). Interestingly, LTM functioning differs according to the ID etiology (Jarrold et al., 2007; Van der Molen et al., 2007).

To further shed light on LTM verbal abilities of adults with mild ID (of mixed etiologies), the current study used a PE paradigm. In four PE experiments, half of the study items were learned by vocal production, and the remaining half by no-production. The participants learned different study lists of familiar images, unfamiliar images, written words, and written text. As expected, a PE was documented for three types of study material; namely, familiar images, written words, and written text. Surprisingly, no PE was documented with a list of unfamiliar, rare images. Next, we will explain these results, and describe their theoretical and clinical implications.

Production Benefits for Adults with ID

The main result of this study is a production benefit for several types of study items (familiar images, written words, and text) in a group of adults with mild ID. As their LTM abilities are impaired (Vicari et al., 2016), memorizing forms a challenge for these individuals. The results suggest that vocal production may compensate for such difficulties, resulting in improved memory performance.

Our pattern of results is consistent with the encoding distinctiveness account of the PE (MacLeod et al., 2010). MacLeod and his colleagues posited that the PE results from enhanced distinctiveness at study. Produced items have associated with them additional unique information that can be successfully used at test for discriminating produced item from other items (and thus for confirming produced items as having been studied; Ozubko et al., 2012).

Importantly, the presence of a PE confirms that adults with mild ID can benefit from the relative distinctiveness of items at study. Distinctiveness is a relative term, as produced items are only distinctive relative to non-produced items. Thus, vocal production is beneficial when both types of study conditions occurred at study. From a review of the pertinent literature, it is not clear whether adults with ID can benefit from encoding distinctiveness (McDaniel & Einstein, 1993). The current results suggest that they can. Thus, the relative nature of the PE could be used to enhance memory performance for this population.

Nevertheless, the results may also be in accord with an attentional account of the PE (MacDonald & MacLeod, 1998; Mama & Icht, 2019; Mama et al., 2018; Ozubko et al., 2012). Accordingly, at study, participants allocate more attentional resources to items that are produced relative to the non-produced items. This process of focusing attention towards a selected portion of the study material yields enhanced memory performance. Many individuals with ID have attention difficulties (Djuric-Zdravkovic et al., 2010), adversely affecting every-day functioning (e.g., learning, behavior, perceptive, and motor functions; Deutsch et al., 2008). The current results suggest that adults with ID can successfully produce target items (words, sentences), enhancing their memory on the backdrop of the remaining unproduced study material. This simple manipulation improves the ability to direct attention to the relevant items, resulting in improved memory.

From the clinical perspective, the current results suggest that vocal production can easily be used in educational and therapeutic contexts for adults with ID. For example, individuals with ID often show movement problems and limitations in mobility (Enkelaar et al., 2012). Thus, they experience difficulties in walking and transferring (e.g., moving from a wheel chair to a toilet seat or from a chair to a bed). Physiotherapists and occupational therapists provide these patients with sequences of motor steps that enable safe and easy movements. Vocalization of a list of movements may assist in remembering them, hence improving balance and gait capacities, reducing the risk of injury (e.g., prevention of falls). Similarly, vocal production may improve the compliance of adults with ID with their medicine administration protocol. As noted by Van Den Bemt et al. (2007), drug administration to individuals with ID is prone to serious errors, because the patients themselves are not alert and therefore cannot intervene when an error occurs. Saying aloud the names of specific medications, the doses to be taken, and their schedule may assist in better remembering, reducing the number of drug administration errors. Vocalization may be also used in order to better follow specific dietary recommendations to improve the nutritional status and safety of individuals with ID (e.g., appropriate texture-modified foods and thickened fluids; Icht et al., 2018).

To assist individuals with ID in becoming increasingly independent, caregivers, teachers and staff-members often use visual supports such as picture and written words presented in different formats (e.g., VAS). The visual cues are used to teach a range of skills, including daily living, vocational, leisure, academic and navigation (for a review of studies, see: Spriggs et al., 2017). The current results suggest that in order to improve the implementation of visual supports in meaningful contexts, vocal production of the visual cues can be easily and effectively used, increasing on-task and transition behaviors.

Considering vocalization as a mnemonic in this population, it is important to note that many adults with ID demonstrate speech difficulties and their speech intelligibility is reduced (Icht, 2019; Terband et al., 2018). Their verbal output is difficult to understand, characterized by an overall high error rate and the occurrence of both typical and atypical phonological processes (Coppens-Hofman et al., 2016). Therefore, individuals with ID and their caregivers and family members are sometimes advised to use alternative communication methods (such as pointing or gesturing), or assistive technology (e.g., augmentative communication device, picture symbols) to better communicate (Dawe, 2006). Yet, speech is the main means of communication for individuals with mild and moderate ID (Terband et al., 2018). Importantly, the current results indicate that the effort of saying aloud, even if in a less clear and accurate manner, is worthwhile, assisting in cognitive (memory) performance. Thus, it is advisable to encourage adults with ID to communicate verbally (for similar conclusions in adults with dysarthria, see, Icht et al., 2019).

No PE for Unfamiliar Images

The other interesting finding of Experiment 1 was a lack of a PE for studying images of rare, unfamiliar objects, contrary to our hypothesis (based on previous findings; Icht & Mama, 2015; MacLeod et al., 2010). As discussed above, we assume that the absence of a PE for such words may be due to (a) the lack of stored phonological representations in the mental lexicon for these items (related to limitations in working memory capacity; Gathercole et al., 1997), (b) poor lexical representations (of the whole word forms), or (c) weak semantic representations of these referents, along weak association between the three (Storkel, 2001). A similar rationale explains the lack of a generation effect for nonwords or unfamiliar words (Hirshman & Bjork, 1988; Slamecka & Graf, 1978).

The word frequency in a specific language is an important variable of the efficiency of its processing in a range of tasks (Rugg, 1990). Generally, word frequency reflects the relative ease with which words of differing frequencies access (or activate) their stored lexical representations. In the current study, although the expected advantage of vocalization did not occur for unfamiliar images, the participants have performed the task satisfactorily, with mean recognition rates of about 70% for both types of words, produced as well as non-produced. A similar recognition rate was found for aloud written familiar words (a recent research review by Lifshitz-Vahav & Vakil, 2014 found that individuals with nonspecific ID can achieve the same level of recognition as individuals with TD). Thus, the present results do not suggest a selective deficit in learning nonwords (a pattern that has been previously reported; Baddeley, 1993; Vallar & Baddeley, 1984), but rather the insufficient gain of saying aloud the non-familiar phonological or lexical forms.

Future studies may further assess studying unfamiliar items within the context of the PE, using study lists of familiar and unfamiliar words. Usually, uncommon events are distinctive with respect to the local context (Einstein &

McDaniel, 1990). Such distinctiveness may cause the participant to perceive the unfamiliar event as unique and different, improving their memory. Such a procedure may be appropriate for assessing the combined effect of familiarity and production.

Limitations and Future Recommendations

The current participant group was composed of mixed etiologies. Given the different memory profiles of individuals with ID of different etiologies (Vicari et al., 2016), future studies should focus on more homogeneous groups of participants (e.g., Down syndrome, fragile-X syndrome), and evaluate their specific verbal LTM profiles.

The literature shows that many kinds of specific productions (other than saying aloud) improve memory, such as spelling, writing, typing, mouthing, and whispering (Forrin et al., 2012). Further studies should examine other productions within the special population of individuals with ID. Additionally, it may be interesting to test the PE using aurally presented stimuli (Mama & Icht, 2016a), as in many daily situations the to-be-remembered material is delivered via the auditory modality (e.g., spoken instructions).

Construction of intervention programs and support plans for adults with ID based on the advantages of vocal production is warranted. Such support might enhance their ability to live as autonomous a life as possible, which is likely to result in a higher perceived quality of life. Evaluating the efficacy of such programs is recommended in future studies.

Conclusions

The presence of a production benefit for different types of material (familiar images, written words, and written text) supports using the simple act of vocalizing as a memorizing tool in the special population of adults with ID, who typically show LTM deficits. This mnemonic may be easily used in many everyday situations as well as within therapeutic and educational contexts.

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Ethics Approval and Consent to Participate

This study was approved by the Institutional Ethics Committee, Ariel University. Potential participants and their parents or legal representatives received written and oral information on the study, after which their written consent was obtained. All participants gave their oral consent.

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