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GRAPHIC TRANSMUTATIONS IDENTIFY THE PHENOMENON OF MEANINGLESS PICTURES REMEMBERED AS FAMILIAR OBJECTS

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Abstract

When asked to reproduce abstract figures from memory, people with brain damage may draw meaningful figures or add extra features unrelated to the original stimulus. Such a phenomenon has been classified as an uncommon type of confabulation. However, this interpretation is unsatisfactory. The aim of this study was to revisit this phenomenon to provide a more robust interpretation.

The records of 496 people presenting with cognitive complaints have been reviewed. Their copy and their reproduction by memory of the Rey-Osterrieth Complex Figure were analysed.

Sixteen people presented with clear instances of the phenomenon. Although differences in cognitive profiles, including memory and executive functions, were detected in this group compared to the rest of the sample who did not present with the phenomenon, considering this phenomenon as a confabulation is misleading. We suggest that the compulsion to semantically process the meaningless figure as a meaningful object leads to the production of *Graphic Transmutation*. The meaningful object overrides the original due to a failure of monitoring functions associated to a defective visuo-spatial memory. Identifying *Graphic Transmutation* in neuropsychological evaluations may provide valuable insight into the cognitive profile of people with brain damage.

Key Words: Graphic transmutation; Rey-Osterrieth's complex figure; confabulation; semantic.

1. Introduction

Productive symptoms, such as intrusions and perseverations, have been reported in people with brain diseases in drawing tasks, both when drawing from dictation [1] and when copying [2, 3]. A particular phenomenon involves the production of meaningful drawings or the addition of extra features unrelated to the original stimulus in delayed copying tasks when reproducing a meaningless figure from memory. It has been documented in cases of Alzheimer's Disease [4], fronto-temporal dementia [5], Wernicke-Korsakoff syndrome [6] and bilateral medio-basal frontal lesion caused by a ruptured aneurysm (case 7b, [7]).

This phenomenon has been branded as an uncommon type of confabulation [8]; Pelati et al. [9] introduced the term "graphic confabulation" to describe such additional or distorted elements unrelated to the target in delayed drawing tasks. In their retrospective study, 267 individuals with heterogeneous neurodegenerative diseases were asked to copy the Rey-Osterrieth Complex Figure (ROCF – [10,11]) and then reproduce it from memory after a 20-minute delay. Fourteen individuals (4.9%) added unrelated elements or altered its configuration by drawing recognizable figures, like a house, a face, a human silhouette, a fish, or a flower plot. Similar instances of simplifying the ROCF into familiar items such as houses, boats or fish have been reported in 4-5 years old children [11]. This behaviour becomes rarer by age 6 and diminishes with age [11]. Notably, it has never been reported in the healthy adults [12; 13; 14; 15; 16].

This type of graphic production bears some resemblance to confabulations seen in dysexecutive syndromes. Accordingly, it has been labelled also "graphabulation" [6], "graphic confabulatory tendency" [4], "visuo-spatial confabulation" [5], as well as "constructional confabulating behaviour" [9]. However, unlike confabulations, which can occur spontaneously, regardless of the task, stimulus, or testing condition, this phenomenon emerges only during delayed copying of meaningless figures, appearing in highly specific tasks and under precise testing conditions.

The phenomenon has been accounted for also as a manifestation of orientation agnosia [7], tough it is never observed during the copy phase, but only at delay. While it has been linked to amnesia, it has never been reported in cases of pure amnesia, even when performance on the ROCF was impaired [17]. As none of these explanations are fully satisfactory, we suggest that this phenomenon should not be classified as confabulation. Instead, we propose the descriptive term *"Graphic Transmutation"* (GT) to designate the delayed reproduction of the ROCF as a meaningful object.

The aim of this study is to characterize this phenomenon. Pelati et al. [9] noted that when their patients produced a meaningful drawing in the delayed recall phase instead of the abstract ROCF they were exposed to, they appeared to be guided by "automatic semantic processing" (p. 379) during the encoding phase. Similarly, Migliaccio et al. [18] reported three cases whose delayed drawing of the ROCF was clearly influenced by the spontaneous description they provided during the copy phase. We propose that GT could be understood as a specific instance of the generation effect [19], wherein self-generated meaningful labels replace the meaningless configurations presented during encoding (see [20]). To test this hypothesis, we conducted two experiments. The first assessed the performance on the ROCF of a selected sample of people with a variety of cognitive impairments. The second was an ad hoc experiment devised to provide further evidence supporting our hypothesis and offer an account for the patterns of errors presented by the individuals with brain damage.

2. Experiment 1: Delayed drawing in a brain damaged sample

2.1 Material and Methods

2.1.1 Participants

Data from 496 people who attended the Center of Cognitive Disorders and Dementia of the University of Naples "Federico II" due to cognitive complaints for one year (January 2022-January 2023) were scrutinized. A total of 16 patients (11 women and 5 men) presented with GT. From the pool of 480

participants not showing GT (NT group), a convenience subsample of 50 (33 women and 17 men) individuals was drawn to record productive phenomena in the neuropsychological tests under study. These 50 participants were selected by matching demographic variables and Mini-Mental State Examination (MMSE) [21] scores with those of the 16 individuals with GT, according to ranges consistent with those commonly used in normative data (e.g., 60–69 years for age and 9–13 years for education). All patients gave informed consent to participate.

The clinical diagnoses were based on medical history, disease duration, neuropsychological and, when available, neuroimaging data. The diagnoses of participants in the GT sample, the entire NT group, and the subsample of 50 NT participants are reported in Table 1. All participants underwent a comprehensive neuropsychological test battery examining long and short-term verbal and visuo-spatial memory, executive function, fluid intelligence and constructional ability. Demographic and neuropsychological characteristics of the two samples are reported in Table 2.

All experimental procedures followed the ethical standards of the 2024 version of the Declaration of Helsinki. Accordingly, the study received approval by the Federico II Ethics Committee [332/21].

----- Please insert Table 1 and Table 2 about here ----

2.1.2 Procedure

This is a retrospective study. We assessed the presence of GT in the delayed reproduction of the ROCF in the whole sample of 496 individuals. We considered recognizable figures (*e.g.,* house, church, or human face) or unrecognizable drawings that were unrelated to the model at the retrieval phase of the ROCF as instances of GT. Over and above the presence of GT, we considered the count of verbal confabulations, false memories, perseverations, and intrusions in the execution of the ROCF as well as in the following tests: Constructional Apraxia Test, Rey-Auditory Verbal Learning Test, Prose Memory, Attentional Matrices, and Phonological Verbal Fluency.

2.1.3 Tests

Rey-Osterrieth Complex Figure (ROCF)

The ROCF [10; 11; 14] is a bidimensional figure that consists of 18 elements including lines, crosses, triangles, rectangles, and circles. The administration procedure, following Rey's original criteria [10], involves two phases: copy and delayed retrieval. ROCF is presented on an A4 sheet of paper in landscape orientation aligned with the midline of the participant's body. The examinee is instructed to copy the figure on a blank sheet as accurately as possible, without any limit of time. The figure is then removed, and, after a 10-minute delay, the participant is asked to reproduce ROCF from memory (i.e., delayed retrieval phase). In the context of a general neuropsychological assessment, the 10-minute interval is filled by non-visuo-spatial tasks. Drawings at the copy and retrieval phases were scored according to Rey's [10] original criteria: 2 points were given when element is correct and well-placed; 1 point when the element is correct and poorly placed or when it is deformed or incomplete but recognizable and well-placed; ½ point when detail is deformed or incomplete but recognizable and poorly placed and 0 point when element is missing or unrecognizable. The total score for each phase ranges from 0 to a max of 36. In the copy of the ROCF, perseverations were repetitions or overscoring elements in the figure while intrusions were incongruent and unrecognizable elements added to the figure. Global and local elaboration were identified according to the Boston Qualitative Scoring System for the Rey-Osterrieth Complex Figure (BQSS; [42]), which divides the ROCF into sets of elements based on their structural importance. When ≥2 Configural Elements (e.g., the large rectangle, the large triangle, the main diagonals) were reproduced in the ROCF copy, elaboration was classified as global. In contrast, when ≥3 Clusters Elements (e.g., circle and/or lines segments that form a coherent element within the main figure) and Details Elements (e.g., single line segments) were reproduced, elaboration was classified as local.

A neuropsychologist (M.M.) and a neurologist (E.S.) examined the delayed reproductions of the ROCF and vetted the drawings for the presence of GT after a consensus. Recognisable drawings or meaningless figures unrelated to original figure, as well as elements with meaning included in a partial

reproduction of the original stimulus (*e.g.*, an embedded smiley face), according to the BQSS [42], were classified as GT.

Constructional Apraxia Test (CAT)

The Constructional Apraxia Test (CAT; [41]) assesses visuo-constructional abilities using simple visual stimuli. The CAT consists of seven A4 sheets, each containing both different familiar and novel geometric shapes. These figures are localized in the upper half of the sheet and aligned with the midline of the examinee's body. Participants were required to copy the figures in the lower half of the sheet. Drawings were evaluated for accuracy: 2 points were given when the figures were fully faithful to the original model; 1 point was assigned when the reproduction was partially correct, allowing the identification of the original model; 0 points were given when the drawings were unrecognizable compared to the stimulus. The total score ranges from 0 to a max of 14. In the CAT, incongruent and unrecognizable elements added to the figure were classified as intrusions while, perseverations were replications of one or more elements one or multiple times in the model reproduction.

Rey-Auditory Verbal Learning Test (RAVLT)

The Rey-Auditory Verbal Learning Test (RAVLT; [35]) includes the immediate, retrieval, and recognition phases. The immediate phase evaluates learning abilities by requiring the examinee to verbally provide 5 consecutive repetitions of the same 15-word list. Each repetition is scored from 0 to 15 and the max total score is 75. The retrieval phase occurs after a 15-minute delay, during which no verbal tasks are administered. This phase assesses the long-term memory of the previously presented 15-word list. Finally, after an additional 15-minute delay, the recognition phase starts. This is a classical old-new recognition task, where the participant is required to discriminate, within a 30-word list, which word was or was not presented in the original list. In the RAVLT-Immediate and Recall, a word produced which was not included in the original list, and uttered only once, constituted an intrusion. Perseverations were systematic (≥2) repetitions of words present in the list and already produced by the participant, or ≥2 repetitions of words not included in the

list. In the RAVLT-Recognition, false memories were words erroneously identified as previously presented in the original list.

Prose Memory Test

Prose Memory [34] requires the participant to repeat immediately and after a 10-minute delay a short story read aloud by the examiner. The max total score is 16, which is derived by the sum of the scores achieved in both the immediate and the delayed phases (from 0 to 8 points each). Verbal confabulations were distorted memories of the information presented in the short story, regardless of whether they occurred in the immediate or retrieval phases.

Attentional Matrices Test

The Attentional Matrices Test [37] is employed to assess visual search and selective attention. The test material consists of three numerical matrices, where the examinee is prompted to mark one (“5”), two (“2” and “6”) and three (“1”, “4” and “9”) target numbers, avoiding distracting numbers. Each trial lasts 45 seconds. The total score is the sum of the target numbers correctly crossed out across all trials, ranging from 0 to a max of 60. Perseverations consisted either of target stimuli repetitively marked within a single matrix or keep marking the target stimuli given in the preceding matrix, being the result of proactive interference. Intrusions were defined as any stimuli marked within the matrix that did not correspond to the target stimuli.

Phonological Verbal Fluency

The Phonological Verbal Fluency Test [38] evaluates the generation of language and set shifting. The participant is requested to produce as many different words as possible, beginning with letters “F,” “A” and “S” (except first and family names and geographical names) within 60 seconds for each target letter. The score is the sum of all words correctly produced across the three trials. Intrusions were violations of the given prompt. Perseverations were repetitions of words previously generated.

2.1.4 Statistical analyses

No missing data were detected in the GT group. In people without GT (NT), the proportion of missing values was < 8%, except for the Stroop test, which was excluded from the analyses as missing data exceeded 20%. Descriptive statistics were expressed as frequency and median ± Interquartile Range (IQR) for categorical and quantitative variables, respectively. Between-group comparisons were performed via non-parametric analyses (*i.e.*, Pearson's asymptotic or Fisher's exact 2-way χ^2 test, Mann-Whitney U test), as appropriate. Binary logistic regression was run to predict group membership (GT coded 0 = no, 1 = yes) from demographic (*i.e.*, biological sex, age, years of education), clinical (*i.e.*, disease duration, BADL, IADL, NPI), and cognitive variables (*i.e.*, the neuropsychological test scores). A similar approach was envisaged to investigate the explanatory contribution of productive phenomena. For screening purposes, each variable was first entered into a univariable logistic regression model. Overall model fit was evaluated using two complementary indices: the omnibus chi squared (χ^2) likelihood ratio test, where statistical significance indicating that the full model predicted group membership better than the null model (with no predictors), and Nagelkerke's R^2, which expresses the proportion of variance in group membership accounted for by the predictor(s). Wald χ^2 was used to test the significance of individual coefficients. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported for each predictor. Categorical predictors entered the models if all expected frequencies in contingency tables were ≥ 5. For quantitative factors, the linearity-of-the-logit assumption was tested by including both the predictor (k) and its interaction with the natural logarithm ($\ln(k)$). A significant interaction term indicated this assumption was violated [43]. Under such circumstances, some data transformations, including reciprocal, square root, natural logarithm, quadratic, cubic, or categorical recording, were tested to restore model validity. About reciprocal and logarithm transformations, a positive shift of +1 was added to handle zero values. The transformation yielding the greatest reduction in the Wald χ^2 associated with the interaction term was selected. Predictors with significant associations with the logit were then entered into a multivariable logistic regression using backward stepwise selection. Multicollinearity was assessed with variance inflation factors (VIFs) and

tolerance values. VIFs greater than 5 and tolerance values less than 0.1 suggested the presence of problematic multicollinearity [44]. Sample size adequacy for the multivariable regression approach followed the conventional rule of at least 10 observations per k [45]. Nominal alpha level was set at 0.05. In all analyses, cases with missing data were handled by listwise deletion. Statistical analyses were performed using IBM SPSS Statistics v. 27 [46].

2.2 Results

2.2.1 Demographic, clinical and standardised neuropsychological profiles

As shown in Table 2, people presenting with GT and those who did not were statistically matched in terms of demographic and general clinical profiles. Specifically, no differences were observed in sociodemographic data, disease duration, scales of daily functions, and neuropsychiatric symptoms. As regards the formal neuropsychological assessment, several between-group differences emerged. Specifically, compared with NT participants, those in the GT group got significantly lower scores on the MMSE ($U = 1920.50$, $p = 0.004$, $r = 0.14$), both immediate ($U = 2276.50$, $p = 0.029$, $r = 0.10$) and delayed components ($U = 2262.00$, $p = 0.027$, $r = 0.11$) of the RAVLT, prose memory ($U = 2122.00$, $p = 0.012$, $r = 0.12$), FAB ($U = 2236.00$, $p = 0.023$, $r = 0.11$), Attentional Matrices ($U = 2088.50$, $p = 0.010$, $r = 0.12$), FAS Fluency ($U = 2135.50$, $p = 0.014$, $r = 0.12$), CPM47 ($U = 2278.50$, $p = 0.029$, $r = 0.10$), CAT ($U = 2206.50$, $p = 0.019$, $r = 0.11$) and, unsurprisingly, on the delayed recall of the ROCF ($U = 2204.00$, $p = 0.019$, $r = 0.11$). Yet, none of these differences survived adjustment for multiple comparisons (e.g., Bonferroni, false discovery rate). Results of the univariable logistic regression models are reported in Table 3. Using MMSE score (dummy-coded) as predictor variable yielded a statistically significant model ($\chi^2 = 4.49$, $p = 0.034$; Nagelkerke's $R^2 = 0.036$). Participants with MMSE scores below the sample median had more than threefold higher odds of belonging to the GT group compared with those with higher scores. Similarly, the model including the CAT score (dummy-coded) was significant ($\chi^2 = 7.38$, $p = 0.007$, Nagelkerke's $R^2 = 0.060$), with participants scoring below the median showing more than fourfold higher odds of GT classification. Among the

quantitative predictors, RAVLT-Immediate, Prose Memory, ROCF-Delayed, Attentional Matrices, and FAS Fluency were significantly associated with group membership, with each unit increase reducing the odds of GT classification by approximately 4–12%. Overall, Nagelkerke's R^2indicated that each of these models explained roughly 5% of the variance. The variables that were significant in the univariate regressions were entered into a multivariable binary logistic regression with backward elimination. Diagnostic checks indicated no evidence of multicollinearity, with VIFs being consistently below 2 and tolerance values above 0.5. The analysis converged at the seventh iteration, yielding not only the most parsimonious solution but also the only model that included a predictor significantly associated with the logit. This model (χ^2= 7.61, p = 0.006, Nagelkerke's R^2 = 0.063) retained the CAT score, which provided a unique independent contribution to group classification (b = 1.487, SE = 0.586, Wald = 6.446, p = 0.011, OR: 4.423 [1.404–13.937]).

----- Please insert Table 3 about here -----

2.2.2 Analyses on qualitative performance

The convenience subsample of 50 NT individuals was statistically equivalent to the GT group with respect to sex (χ^2= 0.04, p = 0.839), age (U = 405.50, p = 0.934), education (U = 427.50 p = 0.667), disease duration (U = 434.50 p = 0.602), functional autonomies (BADL: U = 339.50 p = 0.302; IADL: U = 373.50 p = 0.668), neuropsychiatric symptoms (U = 417.50 p = 0.793), and global cognitive functioning (U = 295.00 p = 0.115). As shown in Table 4, no disproportionate distribution of productive signs was observed across groups, apart from perseverations in the ROCF copy. Specifically, the GT group showed a higher frequency of perseverations than expected under the null hypothesis (11 vs 7.5), whereas the NT subsample showed fewer perseverations than expected (20 vs 23.5). This difference approached statistical significance (χ^2= 4.02, p = 0.045, Φ = 0.25, adjusted residuals = ± 2.0), indicating a tendency for perseverative errors to be more common in the GT group. By emulating the analytical algorithm applied to demographic and clinical data, we attempted to

model productive signs through univariate logistic regressions. Since most productive phenomena produced contingency tables with expected cell counts < 5, only perseveration counts in the ROCF copy, immediate recall of the RAVLT, and Phonological Verbal Fluency (FAS) were used as predictors. The model including perseverations in the ROCF copy emerged as the sole reliable one (χ^2= 4.08, p = 0.043), explaining about 9% of the variance (Nagelkerke's R^2 = 0.089). However, the predictor itself bordered statistical significance [b = 1.294, SE = 0.612, Wald = 3.809, p = 0.051, OR: 3.300 [0.995–10.956]. Accordingly, one could assume that the presence of perseverations might be associated with an increase in the likelihood of GT classification. Finally, it should be noted that, in the ROCF copy, the GT group produced a significantly lower number of correct and well-placed elements compared with the NT subsample (GT: 5.50 ± 7.50 vs. NT: 8.50 ± 9.00; U = 252.00, p = 0.026, r = 0.27), whereas the number of missing or unrecognisable elements was significantly higher (GT: 3.00 ± 2.75 vs. NT: 2.00 ± 4.00; U = 536.50, p = 0.037, r = 0.26). By contrast, no group differences were observed in the number of elements that were correct but poorly placed, deformed or incomplete yet recognisable and well-placed, or deformed or incomplete yet recognisable and poorly placed (all $p_s \geq 0.12$). Still, a marked between-group difference was recorded in the use of local processing (χ^2= 18.389, p <0.001, Φ = 0.53, adjusted residuals = ± 4.3). The GT group showed a significantly higher frequency of cases without local processing than expected (13 vs 5.8) while the NT subsample showed a higher frequency of cases with local processing than expected (39 vs 31.8). Conversely, no difference emerged in terms of global processing (χ^2= 0.874, p = 0.493). Furthermore, neither people with GT nor those without GT rotated the figure, by reorienting the sagittal axis with the triangular part of the figure pointed upwards, during the copy.

---- Please insert Table 4 about here -----

2.2.3 Graphic Trasmutations

The productive phenomena of the 16 people with GT are presented in Figure 1. The drawings of 16 individuals selected from the control group are depicted in Figure 2 for comparison.

----- Please insert Figure 1 and Figure 2 about here -----

Most of the GTs refer to buildings. GT1, GT3, GT5, GT6, GT8, GT11, GT12 and GT14 drew a house. All these participants had memory deficits. GT1, GT3 and GT5 clearly explained what they drew. Some of them presented with neuropsychiatric symptoms: GT3 had coprolalia, GT8 had episodes of verbal disinhibition, and GT14 presented with phobia of loneliness. GT2 drew a cemetery; spontaneously, she described to the examiner details of her drawing, explaining what it was. She presented with psychiatric symptoms, including visual hallucinations (she reported seeing white cotton threads between the fingers of her hands), and had memory deficits. GT9 reproduced a factory. The participant's caregiver referred to episodes of coprolalia and episodes of craving for sweet foods. GT7 drew a church with a human figure floating above the roof and a face on the left side. He presented with memory impairment, religious hallucinations (he claimed to see Padre–Father–Pio, a venerated Italian mystic) and repetitive motor mouth stereotypies.

A second category of GT was represented by figures or elements that remind human features. GT15 drew a face with hair and nose. She had memory impairments but no psychiatric symptoms. GT16 drew a human silhouette with head, arms, and chest. GT10 and GT13 drew a smiley face inside a partial reproduction of the original figure. They should be considered as mild transmutations [42].

Finally, GT4 drew a pattern unrelated to the original figure; she had memory deficits but no psychiatric symptoms.

2.2.4 Follow-up

We could retest nine participants (5 GT and 4 NT) after 2 years with the same neuropsychological battery. As expected, given the nature of their deficits, in all instances, their cognitive profile had worsened in several domains. Two of them, GT10 and GT16 did not show GT at follow-up. Three of the GT presented again with productive phenomena when drawing the ROCF from memory at the retrieval phase. One, GT6 reproduced the same transmutation as before. In the other two cases, the production was confabulatory but different from the previous one; GT14 drew a house with a smiley face, GT7 drew a figure completely unrelated to the original (see in detail in [18]). None of the NT presented productive phenomena in the delayed drawing. Comparison of the ROCF delayed between the first neuropsychological assessment and the follow-up in seven re-tested patients was shown in Figure 3.

----- Please insert Figure 3 about here -----

2.3 Discussion

In this retrospective study, we report on the phenomenon of GT, which occurs during the retrieval phase of the ROCF, when participants are asked to reproduce the complex figure from memory. Among our sample of 496 individuals with brain damage and cognitive impairments, the prevalence of this phenomenon was relatively low (3.24%). This finding aligns with the only other large-sample study available; Pelati et al. [9] observed the phenomenon in 4.9% of people with neurodegenerative disorders in a sample of 267 individuals. In our study, people committing GT had profiles not dissimilar from those of the people not showing the phenomenon (NT) in terms of sociodemographic variables, disease duration, neuropsychiatric symptoms, and functional autonomy. Conversely, GT differed in global cognitive functioning, showing impairments in several cognitive domains, compared to NT group. These findings are partially consistent with those of Venneri et al. [4] and Pelati et al. [9].

At follow up, about two years later, we found that all participants who could be retested showed a decline in their cognitive profile. However, some did not replicate the phenomenon of GT, while others presented it again but produced a different meaningful graphic reproduction. One participant, though, drew a figure similar to their initial GT (Figure 3).

The most common GT were drawings resembling a house or an upright building (11 of 16), which requires rotating the figure counter clockwise by 90 degrees. When rotated, elements 2 and 13 [13] of the ROCF outline a house (see Fig.1b in [9]). This phenomenon is akin to that observed in people with Orientation Agnosia [47]. Solms et al. [7] described 16 people with different type of brain damage, who rotated the whole drawing at the copy phase of the ROCF, by reorienting the sagittal axis of the figure, with the triangular part of the figure pointed upwards, as if it were a roof. This rotated configuration was maintained in the delayed reproduction of the ROCF [7]. Given the impoverishment of graphic details usually observed in the retrieval phase of the ROCF, such drawings may look like recognizable houses, just like in GT. However, typically agnosia for object orientation is observed also in copying and concerns nameable objects that are misoriented even if correctly recognized. In our study, no participant rotated the ROCF upwards at copy phase, and there was no indication of spontaneous instances of Orientation Agnosia [48; 49] (see review by [50]).

Additionally, the main elements of houses and buildings depicted in GTs may evoke Configural Elements of ROCF (i.e., large rectangle or large triangle), typically reproduced when a global elaboration was used. According to Navon [51], healthy individuals first automatically process the overall features of a visual scene (global processing), followed by the details (local processing). Fragmentation of global elements in copy of ROCF has been associated to cognitive impairments, such as PD [52] and AD [53], and a local processing bias was observed in neurological syndrome, such as autism spectrum disorder [54]. In contrast, most of our participants with GT showed a reduced tendency to process local elements. Specifically, qualitative analysis showed a significantly higher number of participants exhibited GT who did not engage in local

processing compared to NT group whereas, no difference on global processing emerged between two groups. However, organizational strategy during copy of ROCF represents a predictor of recall accuracy [55]. Newman and Krikorian [56] confirmed that an organized global approach during encoding leads to better recall accuracy on the ROCF compared to a segmented approach. In our study, the tendency of participants with GT to ignore local elements, associated to a higher number of missing and unrecognizable elements and fewer correctly reproduced elements during ROCF copy compared to NT group, did not clarify the copying strategy approach employed by our GT sample. Regardless, these findings may suggest that visuospatial copying strategy was not involved in GT occurrence.

In our sample, as in previous reports [4; 9], GT occurred after a certain time delay, with individuals showing GT following a 10-minute delay. Moreover, our patients presenting with GT had poor performance on long-term memory tasks compared to NT group. Similarly, Roh [6] described a single-case study of a person with Wernicke-Korsakoff's syndrome who increasingly added extra meaningful details to her delayed reproduction of the ROCF as more time elapsed between presentation and retrieval. Although these findings suggest that memory deficits may play a role in eliciting GT, this productive symptom is rarely observed in cases of dense amnesia (see example in Fig. 1 by [7], case 7b). Kixmiller et al. [17] reported that people with Korsakoff's syndrome exhibited poor performance on the ROCF, with errors including omissions, misplacements, and disproportionate figural details during the immediate copy of the ROCF. These errors persisted leading to impaired performance at delayed retrieval, yet none of the participants showed any instance of GT. People with amnesia due to other causes, including anterior communicating artery aneurysm [57], hippocampal or perirhinal cortex lesions [58] also presented with the same pattern of overall poor performance on the ROCF delayed, but without any evidence of GT. Similarly, detailed reports of single cases with dense amnesia described the poor performance at the ROCF but GT is never mentioned (e.g., [59; 60]). Hence, memory deficits appear to be not sufficient per se to elicit GT.

There is some indication that participants with GT performed poorly on executive functions tests. Moreover, considering qualitative signs, the number of participants showing perseverations in the copy phase of the ROCF was higher in people with GT than in those without. This result aligns with the observation by Sedda et al. [5]. They reported grapho-motor productive phenomena (*e.g.*, perseverations) associated with a dysexecutive syndrome in a person (called BM) with fronto-temporal dementia without overt memory deficits presenting with GT at the ROCF as well as in other tests (Trail Making Test) requiring following a pattern. In both instances, the patient drew a fish. Patient BM showed perseverative behaviour also during a copy task of a geometric pattern. In contrast, people with GT did not show perseverations or productive phenomena in constructional tests, such as CAT [41] and CDT [40], which are frequent in patients with frontal-sub-cortical dysfunction [61].

Executive impairments observed in GTs are consistent with the neuropsychological literature indicating that verbal confabulation is often associated with poor performance on executive tasks (e.g., [62; 63; 64; 65; 66; 67]).

Patients affected by different forms of neurodegeneration often manifest verbal confabulations (e.g., [68]), but GTs are rarely reported. Only a few studies on Alzheimer's Disease and other neurodegenerative conditions have documented the co-occurrence of confabulations and GTs [9; 4]. In our study, 3 out of 16 participants showing GT also made intrusions or verbal confabulations in Prose Memory as well as 3 NT individuals. However, given the small number of people with both GT and verbal confabulations and the occurrence of verbal confabulations without GT, we cannot support the view positing that GT is a supra-modal phenomenon akin to verbal confabulations. Similarly, the lack of verbal confabulations in FTD patient described by Sedda et al. [5], could indicate a possible dissociation between verbal confabulation and GT.

Considered together, the results from the current study challenge the hypothesis that memory or dysexecutive deficits alone are sufficient to elicit GT, as seen in verbal confabulations [69; 70; 71; 72; 73]. Individuals in this study reproduced at delayed retrieval the original meaningless figure or its

elements as recognizable meaningful objects, such as buildings or human parts. Semantic processing might have played a role in these GT. Pelati et al. [9] suggested that a semantic mechanism was underlying GT because of an automatic activation of semantic representations during copying. Such semantic activations would interfere with the memory for meaningless graphic elements in amnesic patients during the retrieval phase.

To test this hypothesis, we set up an experimental study administered to healthy older participants.

3. Experiment 2: Selective interference in healthy controls

3.1 Methods and procedures

We used the procedure of dual tasking [74; 75; 76]. The rationale of the experiment was to “disrupt” the visuo-spatial memory of the participants by means of a secondary task interposed between the presentation of the stimulus materials and the attempt to retrieve them. A total of 14 (7 women) healthy individuals all aged over 65 (M = 68.50 ± 3.46; age range: 65-77 years; level of formal education: M = 10.93 ± 3.60; education range: 8-17 years) participated in this experiment as volunteers. They were asked to observe the ROCF for 3 minutes, during which time the examiner invited them to give a nameable label to the figure according to what it reminded them of (“What does it look like? What does it remind you of?”). Contrary to traditional instructions, participants were not asked to copy the figure. Following this phase, participants were asked to watch a series of 15 (21 cm wide x 12.2 cm high) abstract, two-dimensional, colourful paintings (taken from the work of J. Pollock and other avant-garde artists) presented on a 31 cm x 17.2 cm computer screen by means of software PsychoPy® 2024.1.4 for Windows. Participants were simply asked to judge the pleasantness of the paintings by pressing an “I like it” key or an “I do not like it” key. Each stimulus was randomly repeated twice, for a total of 30 stimuli. There was no time constraint for answering. Following the experimental tasks, participants were engaged in conversation. After an interval of 10 minutes, they were asked to reproduce the ROCF by drawing as per traditional testing

instructions (Figure 4). Two neuropsychologists aware of the definitions of GT for the scope of the present study (see Methods) established consensually whether the participant produced a GT in their drawing.

----- Please insert Figure 4 about here -----

3.2 Results

Seven out of the 12 participants drew at delay figures embedding elements derived from the meaningful labels they gave at encoding to describe the meaningless patters of the ROCF (see Supplementary Material). This did not result in a facilitatory effect, as there was no difference in overall performance at delay between participants who did embed the associated meaningful label and those who did not (ROCF raw score: t = -1.572, df = 11, p = 0.14; ROCF demographically adjusted score: t = -1.504, df = 11, p = 0.16). An incidental finding which was not predicted is a difference in education (t = 2.866, df = 12, p = 0.014, Cohen's d = 1.53) between those who did show GT (mean years = 13.14) and those who did not (mean years = 8.71). However, given the small sample size, this should be replicated in future appraisals.

3.3 Discussion

GT is not observed in normal testing conditions, as healthy participants never show the phenomenon [12; 13; 14; 15; 16]. The outcome from our ad hoc experiment indicates that when visuo-spatial memory is malfunctioning, due to experimental interference, people are more likely to rely on self-generated labels as short-cuts to retrieve encoded information and reproduce a drawing after a delay. It remains to be determined whether specific deficits in visuo-spatial memory (see e.g., [77]), rather than generic memory impairments, are associated with GT.

Drawing a complex meaningless figure from memory is a highly demanding task, requiring visual imagery ([78; see discussion in [79]) and semantic

processing [80]. This was demonstrated experimentally by Bower et al. [81], who showed that meaningless *droodles* (a neologism combining doodle and riddle) were better remembered at delay when a label at encoding activated semantic schemas. This link between the ability to label a picture and subsequent successful retrieval is further demonstrated by studies with children showing that younger participants were more likely to remember a picture during the retrieval phase if they named it aloud [82; 83]. It is much easier to remember complex geometrical figures when giving them a generic label [84].

Carmichael et al. [85] demonstrated that the retrieval of ambiguous figures, which could be interpreted in two ways, for example like a pair of sketched glasses or a handlebar, was influenced by the label given at encoding. When the figure was labelled “glasses”, the participants drew a figure interpretable as glasses at retrieval, on the contrary when the figure was labelled “handlebar”, they depicted a drawing resembling a handlebar. This result is reminiscent of the Encoding Specificity theory of Tulving and Thomson [86] since the identification of the ambiguous figure with a familiar one at encoding could assume the role of contextual cue at retrieval. According to this theory the operations performed at encoding on what is perceived determine what is stored, which in turn would determine retrieval. These encoding operations would be even more effective if based on self-generations of the participants [19] which has been shown to affect also non-verbal material [87], like the ROCF. Notably, the self-generation effect is even more pronounced in people with memory deficits [88; 89; 90].

However, when participants were asked to “give a nameable label to the figure”, a verbal code of the ROCF was induced. In our experimental condition, verbal and visual codes may have been encoded simultaneously, potentially increasing the involvement of *source monitoring* processes during the retrieval phase. According to Johnson [91] source monitoring consists of a “set of processes involved in making attributions about the origins of memories, knowledge, and beliefs”. Although labelling a picture have been shown to facilitate the recall [82; 83], memory distortions have been attributed to a defective source monitoring [92]. Notably, Wheeler et al. [93] argued that

source monitoring may require executive functions to support strategic processes, such as generating attributions based on the qualitative characteristics of the memory record. Deficits in source monitoring have been attributed to poorer executive function in adults and children [94; 95]. Similarly, difficulties in source monitoring reported following frontal damage [92] and impairments in frontal strategic processes [62;72] have been implicated in the occurrence of verbal confabulations.

Overall, these findings suggest that asking participants to assign a label to a complex figure like the ROCF may increase executive demands at retrieval, due to the need to discriminate between verbal and visual memory information.

We propose that similar phenomena could account for GT. When presented with the complex meaningless stimulus of the ROCF to be copied, people may associate it to meaningful objects. If their visual memory capacity is defective and their monitoring system is malfunctioning, then at delay, the self-generated label would overcome the abstract pattern and superimpose to it, generating GT. We recently reported on three cases of people with brain damage whose performance illustrates this hypothesis [18]. During the copy phase of the ROCF, these examinees repeatedly commented on the resemblance of the ROCF to some meaningful objects.

4. General Discussion

The production of drawings at delay representing meaningful and nameable objects instead of the abstract, meaningless probes, is a rare but observable phenomenon. In discussing his Theory of Abstraction [96], Kurt Goldstein showed that some people following brain damage were unable to reproduce reasonable copies of abstract figures from memory unless they managed to name them at encoding (see Fig. 6, p. 162, in [97]). Migliaccio et al. [18] posited that such impairment may underlie GT when cognitive impairments would not allow the inhibition of this interfering semantic processing, or when a compromised visuo-spatial memory system fails to retrieve the original abstract figure.

De Anna et al. [98] and Attali et al. [99] suggested that verbal confabulations may arise from the tendency to replace poorly encoded material with overlearned information at recall. In their experimental memory tasks, they administered to people with AD and healthy participants, three different types of brief stories: one unfamiliar story, one well-known fairy tale (e.g., Snow White or Cinderella) and one modified well-known fairy tale (e.g., Little Red Riding Hood with a different ending). The results showed that AD individuals exhibited significantly more verbal confabulations when recalling the modified fairy tale compared to the other two conditions. This suggests that the activation of the original version of the fairy tale interfered with the encoding of the modified elements, leading to the misidentification of the story and the substitution of the most familiar version, ultimately generating false memories.

The mechanisms underlying the production of GT are different. In the immediate copying task of our study, the meaningless figure was correctly encoded and reproduced. Interference occurs during the retrieval phase, whereby subsequent labelling influences delayed reproduction. In sum, in De Anna et al.'s [98] and Attali et al.'s [99] studies the conflict lies in the encoding phase between the presented story and the representation of the overlearned story in semantic memory; in our study, and in GT in general, the conflict lies in the retrieval phase between the encoded, meaningless stimulus figure and the episodic memory of the assigned meaningful label.

We propose that GT arises from the effect of semantic processing of the original meaningless figure. GT can be understood as a particular aspect of the generation effect coupled with a specific cognitive profile that includes deficits of visuo-spatial memory and monitoring functions. GT may be driven by the meaning that people spontaneously assign when scrutinizing or reproducing a complex abstract figure containing elements interpretable as common objects. When people are unable to reconstruct the original meaningless configuration or are unable to inhibit the memory of the assigned verbal label, GT would emerge. Specific executive functions, including monitoring and inhibition [100], have never been studied within the frame of GT. These, rather than generic executive tests, may offer an insight into the phenomenon. Considering the presence of GT may be valuable to better elucidate the neuropsychological

profile of people following brain damage or with a neurodegenerative disease, especially those seeking evaluation at memory clinics.

This study has some limitations. While the participants are well-characterised clinically, the absence of homogeneous neuroimaging data prevents the identification of the neuroanatomical correlates of GT. Although GT was considered as the result of the combined effect of multiple focal cognitive deficits, patients showing GT exhibited heterogeneous cognitive deficits, which made it difficult to identify consistent associations. The study's retrospective design means that the available tests are not always optimal; for example, verbal confabulations were measured using prose memory rather than with ad hoc confabulation questionnaires.

The selective interference experiment offers interesting hints for the interpretation of the productive phenomenon of GT, but it calls for replication with a larger sample and more controlled experimental conditions. Moreover, the test used in the experiment was different from the typical ROCF as the copying part was skipped. Future experimental designs should consider also copying processes.

Future research should explore the role of visuo-spatial memory deficits and of impairment to specific executive functions, like inhibition and monitoring in eliciting GT. Additionally, observational studies should revamp Goldstein's proposal [97] of a cognitive syndrome that hinders abstraction, leaving people unable to remember meaningless configurations unless processed as meaningful and familiar objects.

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Author contributions

MM contributed to investigation, data curation, and writing – original draft.

ES contributed to project administration, conceptualization, and investigation.

CC contributed to investigation and provided resources.

RC contributed to methodology and writing – review & editing.

SDS contributed to conceptualization, methodology, and writing – review & editing.

All authors reviewed and approved the final manuscript.

Data availability statement

Data analysed in the present study are available from the corresponding author upon request.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Figure Legends

Figure 1. Recall of ROCF by the 16 participants showing graphic transmutation (GT).

Figure 2. Recall of ROCF by the 16 participants not showing graphic transmutation (NT) selected from subsample of 50 participants.

Figure 3. Comparison between recall of the ROCF at the first neuropsychological assessment and at the 2-year follow-up in 7 participants (5 GT and 2 NT). Drawings by two NT participants (NT3 and NT5) are not shown in the figure because they did not recall the ROCF.

Figure 4. Outline of the procedure of Experiment 2.

Table 1. Clinical diagnoses of the participants showing (GT) and not showing (NT) graphic transmutation, including the subsample of 50 NT participants.

	GT (n = 16)	NT total (n = 480)	NT subsample (n = 50)
Alzheimer's Disease (AD)[1]	3	32	5
Amnestic Mild Cognitive Impairment (aMCI)[2]	-	33	3
Anterior Communicating Artery Aneurism[3]	1	1	-
Cortical Basal Degeneration[4]	-	3	1
Epilepsy	-	2	-
Fronto-Temporal Dementia (FTD)[5]	-	8	3
HIV-Associated Dementia	-	3	-
Intellectual Disability	-	6	-
Korsakoff's Syndrome	1	-	-
Lewy Body Dementia[6]	-	2	-
Meningioma	-	3	-
Mild Cognitive Impairment in Parkinson's Disease (MCI-PD)[7]	-	16	-
Mixed Dementia (AD+ Vascular Dementia)[1,8]	-	16	2
Multiple-domain Mild Cognitive Impairment[2]	4	157	11**
Non-amnestic Mild Cognitive Impairment (naMCI)[2]	-	35	9
Normal Pressure Hydrocephalus (NPH)[9]	-	3	-
Parkinson's Disease Dementia (PDD)[10]	1	7	1
Pseudodementia	2*	36	4**
Spastic Paraplegia type 4	-	1	-
Subjective Memory Complaints (SMC)[11]	-	57	4
Traumatic Brain Injury[3]	1	12	2
Uncertain diagnosis[12]	-	9	-
Vascular Dementia (VaD)[8]	3*	37	5**
Wernicke Encephalopathy	-	1	-

[1] According to the NINCDS–ADRDA criteria [22]; [2]According to Peterson's criteria [23]; [3]Confirmed by Magnetic Resonance Imaging; [4]According to Armstrong's criteria [24]; [5]According to Neary's criteria [25]; [6]According to Rizzo' review and meta-analysis [26]; [7]According to Litvan's criteria [27]; [8]According to the VASCOG criteria [28]; [9]Confirmed by Computed Tomography; [10]According to Emre's criteria [29]; [11]According to Abdulrab & Heun's criteria [30]; [12] Insufficient available data for certain diagnosis.
Note: *In VaD: a patient with VaD, Epilepsy and aphasia was included. In pseudodementia: psychiatric diagnosis was bipolar disorder in one case and anxiety/depressive disorder in the other.
**In VaD: a patient with VaD and Normal Pressure Hydrocephalus. In Multiple- domain Mild Cognitive Impairment: a patient with multi-domain MCI and Arnold Chiari malformation type 1 (blurred vision and neuropathic pain). In pseudodementia: Major Depressive Disorder (MDD) in three patients and psychotic disorder in the other.

Table 2. The sociodemographic and neuropsychological characteristics (raw scores) of the participants with (GT) and without (NT) graphic transmutations included in the study. Quantitative variables are expressed as median ± IQR.

Domains	Variables	GT (n = 16)	NT total (n = 480)	p-values
General demographic and clinical profile				
	Sex (w/m)	11/5	244/236	0.158
	Age (years)	68.50 ± 20.00	69.00 ± 14.00	0.736
	Education (years)	6.50 ± 4.50	8.00 ± 8.00	0.132
	Disease duration (years)	4.00 ± 3.00	3.00 ± 3.00	0.394
	BADL	5.00 ± 1.00	6.00 ± 1.00	0.340
	IADL	5.50 ± 2.75	5.00 ± 4.00	0.983
	NPI	28.00 ± 32.25	21.00 ± 29.00	0.477
Neuropsychological assessment				
Global cognitive functioning	MMSE	21.00 ± 6.50	26.00 ± 6.00	**0.004**
Short-term memory	Disyllabic Word Span	3.00 ± 1.75	3.00 ± 1.00	0.141
	Corsi Span	4.00 ± 1.75	4.00 ± 1.00	0.093
Long-term memory	RAVLT-Immediate	21.00 ± 10.75	25.00 ± 15.00	**0.029**
	RAVLT-Delayed	2.00 ± 4.75	4.00 ± 5.00	**0.027**
	RAVLT-Recognition	10.00 ± 6.75	12.00 ± 5.00	0.202
	Prose Memory	4.25 ± 7.28	7.85 ± 7.95	**0.012**
	ROCF-Delayed	3.25 ± 4.75	5.50 ± 10.19	**0.019**
Executive functions	FAB	11.50 ± 4.02	14.00 ± 6.00	**0.023**
	Attentional Matrices	34.50 ± 18.50	42.00 ± 19.00	**0.010**
	Phonological Verbal Fluency (FAS)	15.00 ± 10.75	21.00 ± 16.00	**0.014**
Fluid intelligence	CPM47	15.50 ± 8.50	21.00 ± 12.00	**0.029**
Constructional Ability	CDT	6.00 ± 5.63	7.00 ± 7.12	0.336
	ROCF-Copy	19.00 ± 12.75	24.00 ± 17.50	0.057
	CAT	10.00 ± 2.50	11.00 ± 4.00	**0.019**

Note: BADL = Basic Activities of Daily Living [31]; IADL = Instrumental Activities of Daily Living [32]; NPI = Neuropsychiatric Inventory [33]; MMSE = Mini-Mental State Examination [21]; Disyllabic Word Span [34]; Corsi Span [34]; RAVLT = Rey's Auditory Verbal Learning Test [35]; Prose Memory [34]; ROCF = Rey-Osterrieth Complex Figure ([10],[11], [14]); FAB = Frontal Assessment Battery [36]; Attentional Matrices [37]; Phonological Verbal Fluency [38]; CPM47 = Raven's Coloured Progressive Matrices [39]; CDT = Clock Drawing Test [40]; CAT = Constructional Apraxia Test [41]. Crude significant p-values are highlighted in bold.

Table 3. Results of univariate logistic regression analyses on demographic, clinical, and neuropsychological variables performed on the entire group (n = 496).

Model	Omnibus χ^2 test	Nagelkerke's R^2	*b*	SE	Wald χ^2	OR [95% CI]	*p*-value
Sex	2.004, p = 0.153	0.017	-0.755	0.547	1.905	0.470 [0.161, 1.373]	0.167
Age (years)	0.115, p = 0.735	0.001	-0.008	0.023	0.117	0.992 [0.948, 1.039]	0.732
Education (years)	2.400, p = 0.121	0.005	-0.091	0.062	2.146	0.913 [0.809, 1.031]	0.143
Disease duration (years)	0.486, p = 0.486	0.004	0.022	0.029	0.599	1.023 [0.966, 1.083]	0.439
BADL	0.041, p = 0.840	0.000	0.050	0.251	0.039	1.051 [0.643, 1.717]	0.843
IADL	0.318, p = 0.573	0.003	0.060	0.108	0.312	1.062 [0.859, 1.313]	0.577
NPI	0.171, p = 0.679	0.001	0.005	0.012	0.177	1.005 [0.982, 1.029]	0.674
MMSE (dummy)	4.488, p = 0.034	0.036	1.153	0.585	3.890	3.167 [1.007, 9.960]	**0.049**
Disyllabic Word Span	0.806, p = 0.369	0.007	-0.253	0.280	0.819	0.776 [0.448, 1.344]	0.365
Corsi Span	2.252, p = 0.133	0.018	-0.305	0.196	2.410	0.737 [0.502, 1.083]	0.121
RAVLT-Immediate	4.986, p = 0.026	0.041	-0.055	0.026	4.439	0.947 [0.899, 0.996]	**0.035**
RAVLT-Delayed	4.209, p = 0.040	0.034	-0.163	0.086	3.598	0.849 [0.717, 1.005]	0.058
RAVLT-Recognition	1.749, p = 0.186	0.014	-0.084	0.061	1.908	0.919 [0.816, 1.036]	0.167
Prose Memory	5.521, p = 0.019	0.045	-0.126	0.056	5.014	0.881 [0.789, 0.984]	**0.025**
ROCF-Delayed	5.980, p = 0.014	0.050	-0.120	0.058	4.270	0.887 [0.791, 0.994]	**0.039**
FAB	2.270, p = 0.132	0.018	-0.088	0.057	2.398	0.916 [0.819, 1.024]	0.121
Attentional Matrices	5.406, p = 0.020	0.044	-0.044	0.019	5.493	0.957 [0.923, 0.993]	**0.019**

Phonological Verbal Fluency (FAS)	5.576, p = 0.018	0.046	-0.058	0.026	4.962	0.944 [0.897, 0.993]	**0.026**
CPM47	3.560, p = 0.059	0.029	-0.066	0.036	3.391	0.936 [0.873, 1.004]	0.066
CDT (^{3})	1.685, p = 0.194	0.014	-0.001	0.001	1.553	0.999 [0.998, 1.001]	0.213
ROCF-Copy ($^{-1}$)	0.156, p = 0.693	0.001	-0.795	2.211	0.129	0.452 [0.006, 3.445]	0.719
CAT (dummy)	7.377, p = 0.007	0.060	1.463	0.585	6.256	4.319 [1.372, 13.59]	**0.012**

Note: BADL = Basic Activities of Daily Living [31]; IADL = Instrumental Activities of Daily Living [32]; NPI = Neuropsychiatric Inventory [33]; MMSE = Mini-Mental State Examination [21]; Disyllabic Word Span [34]; Corsi Span [34]; RAVLT = Rey's Auditory Verbal Learning Test [35]; Prose Memory [34]; ROCF = Rey-Osterrieth Complex Figure ([10],[11], [14]); FAB = Frontal Assessment Battery [36]; Attentional Matrices [37]; Phonological Verbal Fluency [38]; CPM47 = Raven's Coloured Progressive Matrices [39]; CDT = Clock Drawing Test [40]; CAT = Constructional Apraxia Test [41]. Sex was coded as 1 = female and 0 = male; the MMSE score was recoded into a dummy variable based on the sample median (Me = 26): 1 = < 26, 0 = ≥ 26; the CAT score was recoded into a dummy variable based on the sample median (Me = 11): 1 = < 11, 0 = ≥ 11. Significant predictors are highlighted in bold.

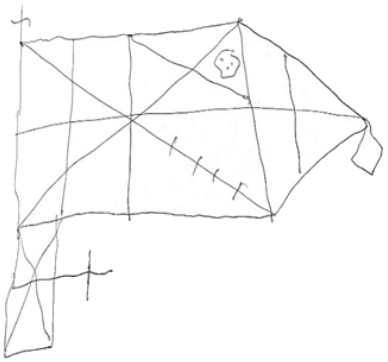
Table 4. Descriptive statistics of productive signs within neuropsychological assessment in the participants showing graphic transmutation (GT) and in the subsample of 50 participants who did not (NT). The number of productive phenomena is expressed as the frequency of individuals exhibiting at least one productive sign.

Neuropsychological measure	Productive phenomena	GT (n = 16)	NT subsample (n = 50)	p-values
ROCF	Intrusions in copy	6	7	0.067
	Perseverations in copy	11	20	**0.045**
CAT	Intrusions	0	0	-
	Perseverations	0	0	-
RAVLT	Intrusions in immediate recall	12	37	0.990
	Perseverations in immediate recall	11	31	0.625
	False memories in old/new recognition	13	39	0.990
Prose Memory	Verbal confabulations	3	3	0.148
Attentional Matrices	Intrusions	1	5	0.990
	Perseverations	3	4	0.347
Phonological Verbal Fluency (FAS)	Intrusions	2	5	0.990
	Perseverations	8	23	0.780

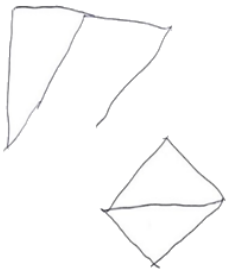
Note: ROCF = Rey-Osterrieth Complex Figure ([10],[11], [14]); CAT = Constructional Apraxia Test [41]; RAVLT = Rey's Auditory Verbal Learning Test [35]; Prose Memory [34]; Attentional Matrices [37]; Phonological Verbal Fluency [38]; Crude significant *p*-values are highlighted in bold.

NT1, 68y, F, MCI

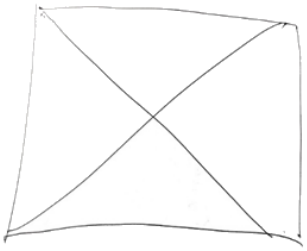
NT2, 56y, M, TBI



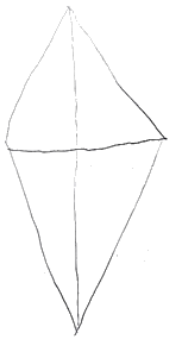
NT3, 69y, F, AD



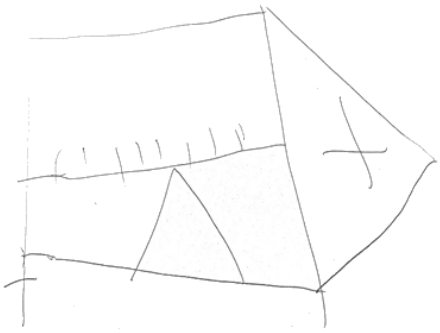
NT4, 81y, M, VD



NT5, 53y, M, AD

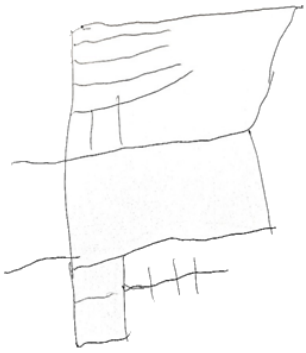


NT6, 50y, M, NHC and VD

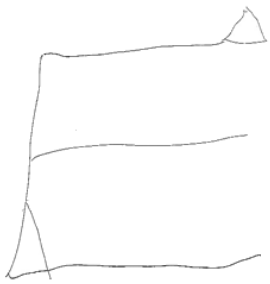


NT7, 80y, M, VD

NT8, 60y, F, MCI



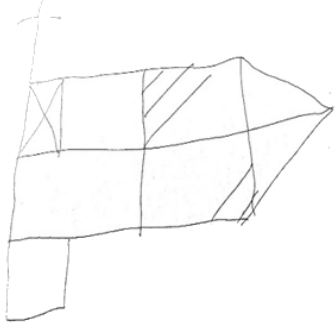
NT9, 83y, F, VD



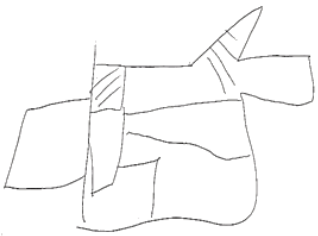
NT10, 68y, F, MCI

NT11, 77y, F, MCI

NT12, 67y, F, MCI



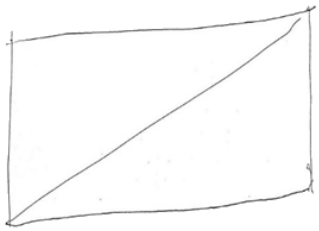
NT13, 63y, M, TBI

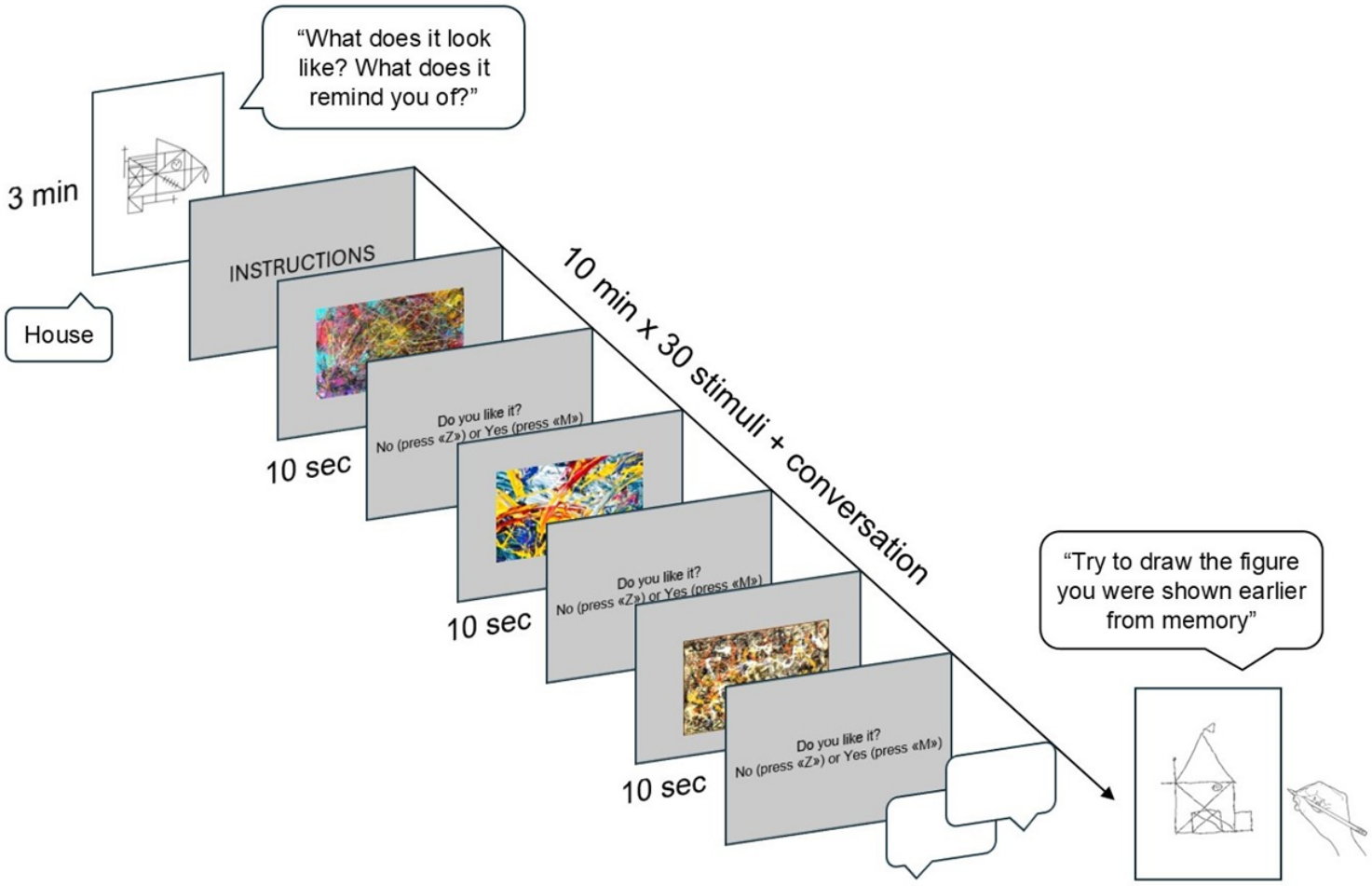


NT14, 59y, F, MCI

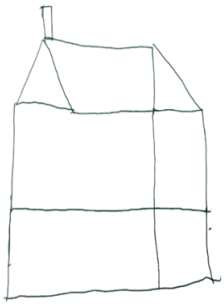
NT15, 57y, F, MCI

NT16, 80y, M, AD

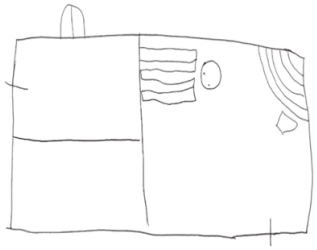



"What does it look like? What does it remind you of?"
3 min
House
INSTRUCTIONS
10 sec
Do you like it?
No (press «Z») or Yes (press «M»)
10 sec
Do you like it?
No (press «Z») or Yes (press «M»)
10 sec
Do you like it?
No (press «Z») or Yes (press «M»)
10 min x 30 stimuli + conversation
"Try to draw the figure you were shown earlier from memory"

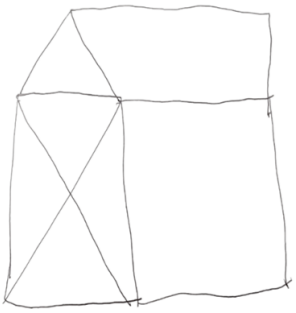
GT1, 71y, F, MCI
HOUSE



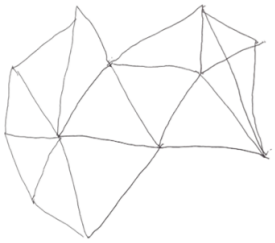
GT2, 52Y, F, BIPOLAR DISORDER
CEMETERY



GT3, 69y, F, AcoA
HOUSE

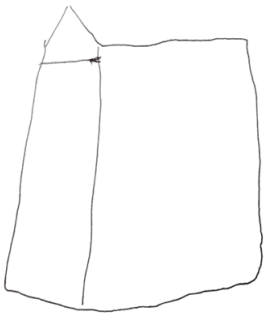


GT4, 82y, F, VD
PATTERN

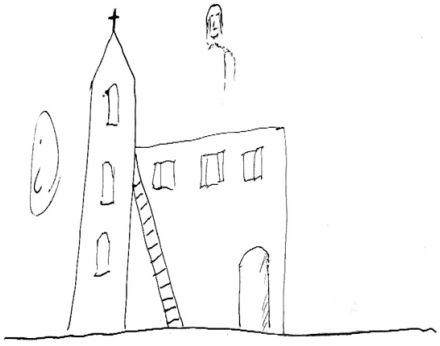


GT5, 53y, M, PDD
HOUSE

GT6, 52y, M, Korsakoff syndrome
HOUSE

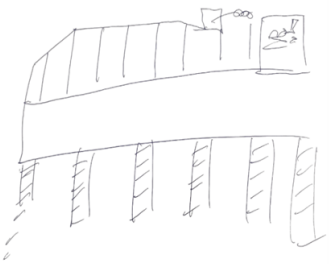


GT7, 81y, M, VD
CHURCH with HUMAN FIGURE



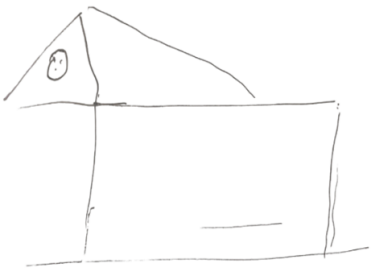
GT8, 61y, F, TBI
HOUSE

GT9, 78y, F, AD
FACTORY

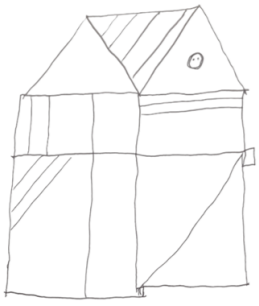


GT10, 70y, F, MCI
HUMAN FACE

GT11, 78y, F, MCI
HOUSE



GT12, 68y, F, MCI
HOUSE

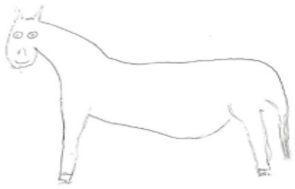
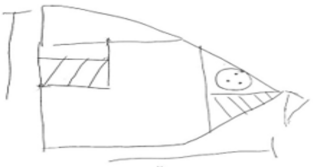
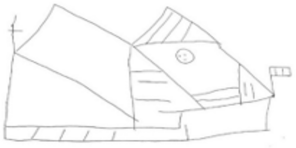
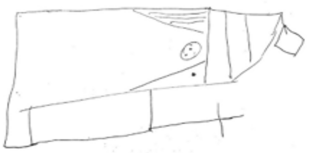
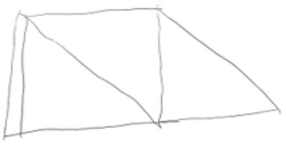
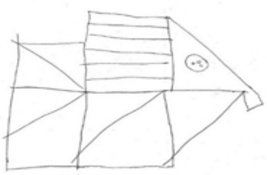
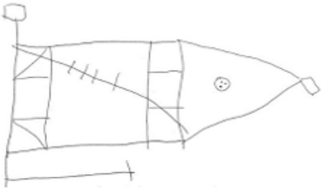


GT13, 62y, M, VD with epilepsy and aphasia
HUMAN FACE

GT14, 58y, F, psychiatric disorder
HOUSE

GT15, 57y, F, AD
HUMAN FACE

GT16, 75y, M, AD
HUMAN SILHOUETTE

	First neuropsychological assessment		*Follow up*	
GT6, 52y, M, Korsakoff syndrome		HOUSE		HOUSE
GT7, 81y, M, VD		CHURCH with HUMAN FIGURE		HORSE
GT10, 70y, F, MCI		HUMAN FACE		NO TRASMUTATION
GT14, 58y, F, psychiatric disorder		HOUSE		HOUSE with HUMAN FACE
GT16, 75y, M, AD		HUMAN SILHOUETTE		NO TRASMUTATION
NT10, 68y, F, MCI		NO TRASMUTATION		NO TRASMUTATION
NT15, 75y, F, MCI		NO TRASMUTATION		NO TRASMUTATION