The Role of Age and Gender in Adult Transverse Patterning Tasks

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Abstract

Within the vast body of literature on pattern discrimination learning, transverse patterning (TP) has become a focus of interest. Whereas non-transverse patterning (NTP) appears to be an easy construction for most humans, TP creates problems for some people. Elaborating on the near/far-range hypothesis for configural performance differences in men and women, and building on the hierarchical construction of complex knowledge, this study investigates the influence of age and gender on TP tasks. In a web-based NTP/TP experiment including 84 psychology students (N = 84), no age-related decline in TP processing has been found. Non-linear analysis even suggests a small improvement in performance with age relative to TP performance. Likewise, no gender-related effect on TP performance was visible in a sample.

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Introduction

Assuming an associative learning paradigm, discrimination learning can be framed as a refinement on generalisation, when a constructively acquired generalisation is not transferrable between similar contexts (Vervliet et al., 2011; Vygotsky, 1938/1987). Within the vast body of literature on pattern discrimination learning, transverse patterning (TP) has become a focus of interest. Whereas non-transverse patterning (NTP) appears to be an easy construction for most humans, TP creates problems for some people.

Literature Review

Transverse patterning appears impaired in amnesic patients, enabling both psychological and neurobiological study of the phenomenon (Reed & Squire, 1999; Rickard & Grafman, 1998). Particularly, involvement of hippocampal function has been reported for TP (Dusek & Eichenbaum, 1998). In a sample of 116 undergraduate students, Carlozzi & Thomas (2008) found TP performance to be associated with spatial processing (mental rotation) rather than memory (r = -.26). TP may thus also involve parietal functions (Tagaris et al., 1998; Alvarado & Bachevalier, 2005). Alvarado & Rudy (1992) found in rat experiments, ambiguity during associative phases appears to create configural knowledge that aids performance during TP transfer tasks (cf. Rickard et al., 2006). An attentional theory has been proposed by Mackintosh (1965). Butt & Bowman (2002) further suggest nucleus basalis magnocellularis lesions as a cause for problems dividing attention between stimuli or strategies.

Metacognitive Influences and Age

Children before the age of ca. 4.5 years were found to only solve configural problems that also permitted an associative solution (Rudy et al., 1993). The recognition of transitive patterns of implication (A if AB, B if BC, ∴ A if AC) transcends association. A fundamental difference in processing of transverse patterning discrimination between children and adults has been proposed by Berch & Israel (1974). Processing speed has been controversially discussed as an explanation for cognitive aging related to working memory, with supposedly small influence on TP tasks (Peng et al., 2012). Whereas Driscoll et al. (2003) suggest age-related decline in TP tasks, Ostreicher et al. (2010) found age-related deficits in TP task to be compensated by schemas that are semantically relevant.

TP requires anti-symmetrical application of transitivity. Formal knowledge about transitivity and implication constitutes meta-knowledge about the associative tasks. Following Commons (2008) hierarchical complexity, implication is formal knowledge (layer 10). TP can be solved meta-systematically (layer 12 post-formal knowledge). For TP tasks, one may apply isomorphism on transitivity of implication, without having to paradigmatically construct a new layer 10 formalism (A if AB, B if BC, ∴ *C if AC*). Hierarchical complexity is thought to improve throughout one's educational lifespan (Commons, 2008; Piaget, 1981).

Influence of Gender on TP Tasks

Little research is found on the influence of gender on TP tasks. While there is some support for a gender difference on configural learning processes, explanations usually involve gender-based difference in spatial difference (near/far range tasks). Coluccia & Louse (2004) based gender-differences on cognitive difficulty. Chamizo et al. (2011) suggest far range tasks are relatively difficult opposed to near-range tasks. Challenging this interpretation, gender-differences may not arise from cognitive difficulty. In a standardised near-range setting with the same cognitive difficulty men and women are then expected to perform similarly.

This study investigates the influence of age and gender on TP tasks. In a NTP vs. TP experiment, it is therefore hypothesized that there is a significant increase in the number of attempts for the TP task over the NTP condition (H1), there is no influence of gender on any of the involved tasks (H2), and there is no age-related increase in the number of attempts necessary in the transverse patterning condition (H3).

Method

Participants

To measure the difference between transverse and non-transverse patterning in discrimination learning, data of 87 university students of psychology was gathered participating in an online learning and memory experiment (OPL, n.d.). Participants were selected by opportunity from students participating in the course (convenience sample).

Design & Materials

In a web-based learning experiment, two different types of transitivity were presented as two sets of transverse and non-transverse patterning tasks each containing three phases: A if AB, B if BC, ∴ A if AC (variables ntp1, ntp2, npt3), immediately followed by a transverse patterning task: A if AB, B if BC, ∴ C if AC (variables tp1, tp2, tp3). A, B, and C were coded by three symbols per set.

Procedure

After entering information about age and gender, participants were presented two symbols in each phase and had to identify the correct symbol by answering which symbol is "hiding a coin" (mouse-click). Participants were transferred to the next stage after 14 consecutive correct answers (minimum phase result = 14). To eliminate processing speed as a marker of cognitive aging, no timing date have been gathered (Peng et al., 2012).

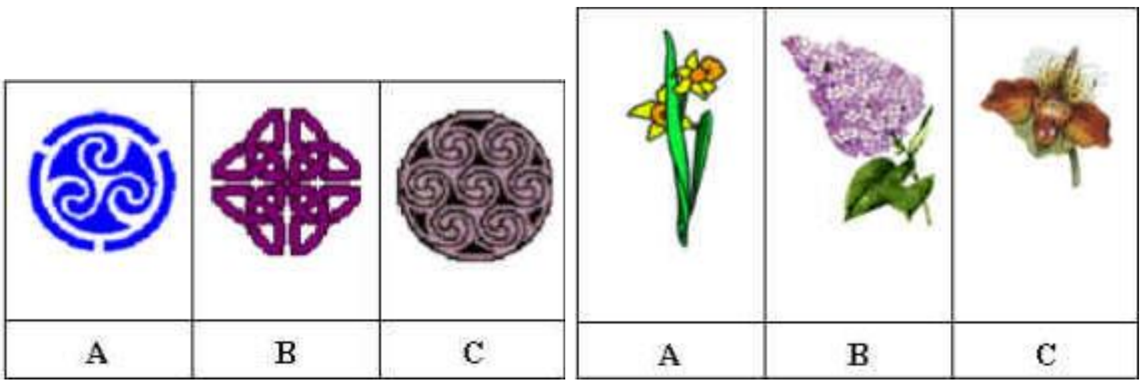

Figure 1. Set Symbols

Results

To examine the effects of transverse presentation on learning, a group of university students was tested with a pictorial transitivity task. 87 individual datasets were obtained.

Data Screening

All datasets were complete for all variables. Three outliers were identified and have been removed from the sample. One participant presented at age 82 and greatly increased attempts exceeding 3 standard deviations at transverse Phase 3 ($tp3$ = 94, M_{tp3} = 26.62, SD = 13.51). Two more outliers presented in the range of 40-50 years of age, exceeding 3 standard deviations ($tp3$ = 336 and $tp3$ = 199). Notably, a small gender-related effect disappeared after eliminating these outliers at baseline: $M_{tp3,f}$ = 32.2, SD = 44.18, n = 54 vs. $M_{tp3,m}$ = 34.12, SD=34.52, n = 33 (pre-screening).

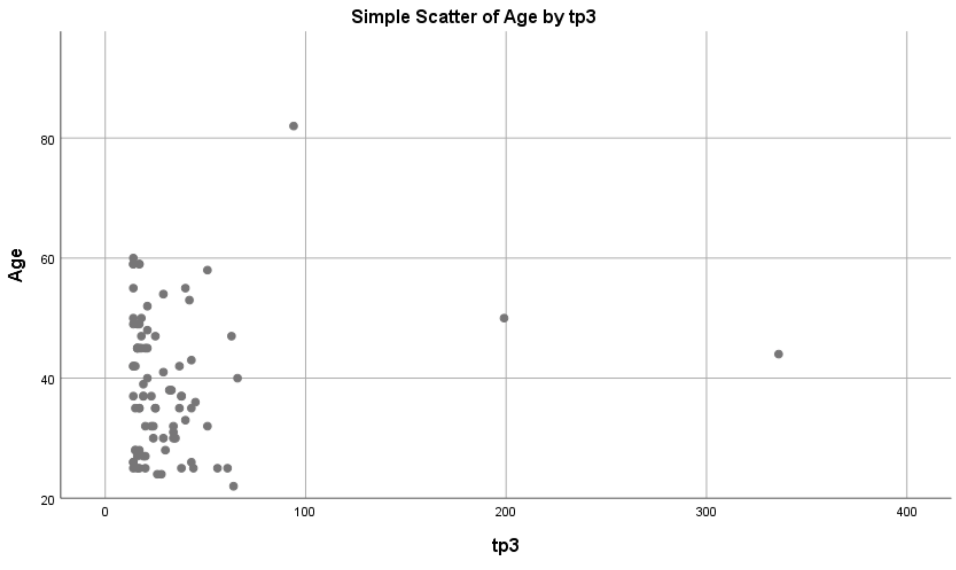

Figure 2. Scatterplot of Age by tp3

General Analysis

There were 84 participants in the final sample (N = 84), including 54 female (n_f = 53) and 31 male (n_m = 33) participants. Age of the participants ranged from 22 to 60 years (M = 38.20, SD = 19.48) and was normally distributed (skewness = 0.42, kurtosis = -0.82), with two peaks at around 26 and 59 years of age, possibly owing to the limited sample size and number of university students in the sample.

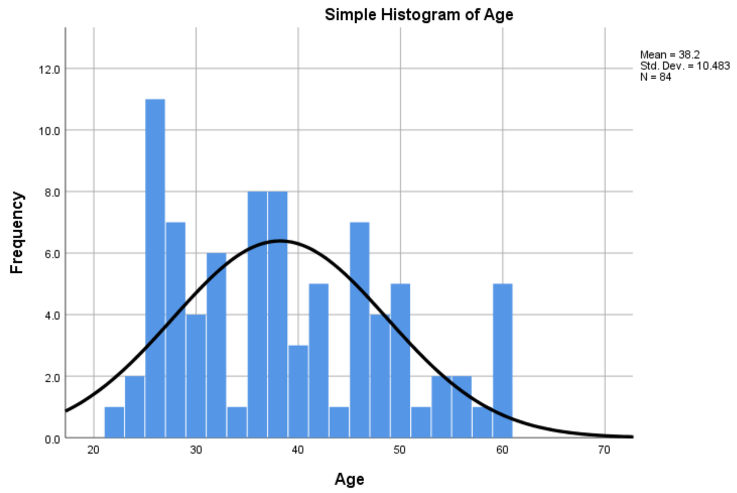

Figure 3. Histogram of Age

Particularly, the peak at 25 years of age contains female, and the peak at 60 years of age contains male participants.

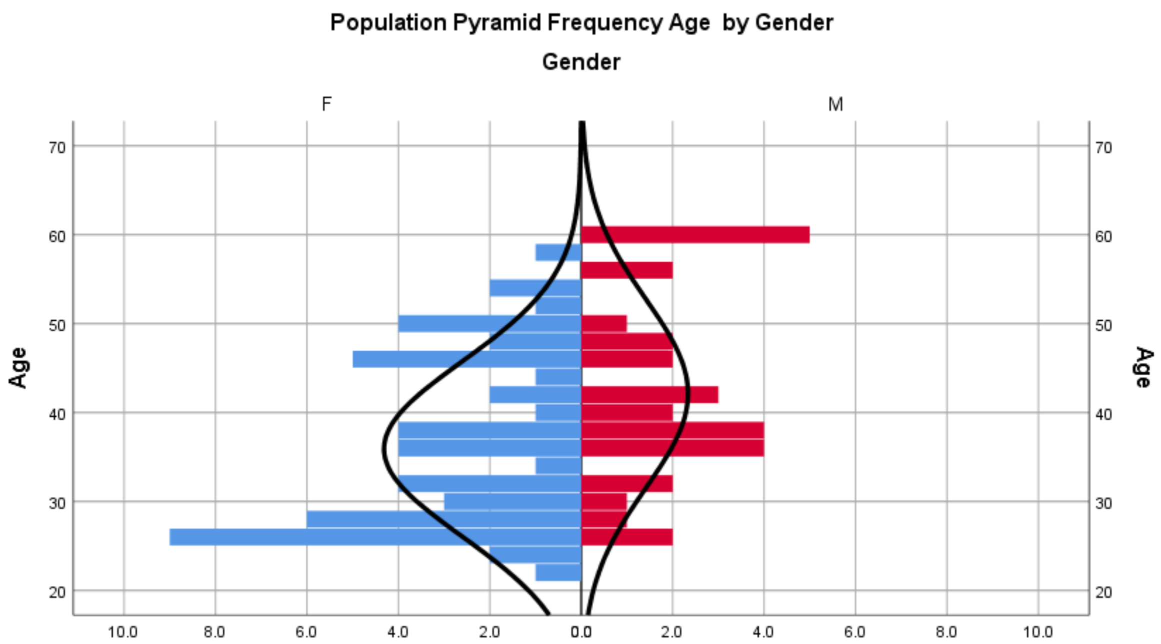

Figure 4. Histogram of Age by Gender

The mean attempts to success and standard deviations for all three phases in both sets are detailed in Table 1.

Table 1

Descriptives

Variable	*M*	Min	Max	Range	*SD*	Skewness	Kurtosis
ntp1	15.67	14	34	20	3.66	2.84	8.91
ntp2	19.85	14	69	55	8.21	3.44	16.02
ntp3	15.19	14	33	19	3.36	3.60	14.07
tp1	14.88	14	28	14	1.79	5.49	36.48
tp2	17.02	14	37	23	4.95	2.02	3.71
tp3	26.62	14	66	52	13.51	1.24	0.83

High values for skewness and kurtosis suggest that the number of attempts is not normally distributed for most groups. To assess the distribution, derived variables etp1 through etp3 and entp1 through entp3 have been calculated, subtracting 14 from each original variable and thus representing the number of mistakes in each phase.

The overall distribution of mistakes appears exponentially distributed. Entp1, enpt3, etp1 and etp2 show considerable floor effects, possibly owing to the relative ease of the tasks for the academic participants. Only a mild floor effect can be found in the tp3 phase. In ntp1 and tp3 tasks, the number of participants making one mistake exceeds those making no mistakes. In tp3, the acquired NTP strategy may have been applied in the first attempt. This shift is missing in ntp1, possibly primed by geometric similarity of ntp1 symbol “A” to a coin.

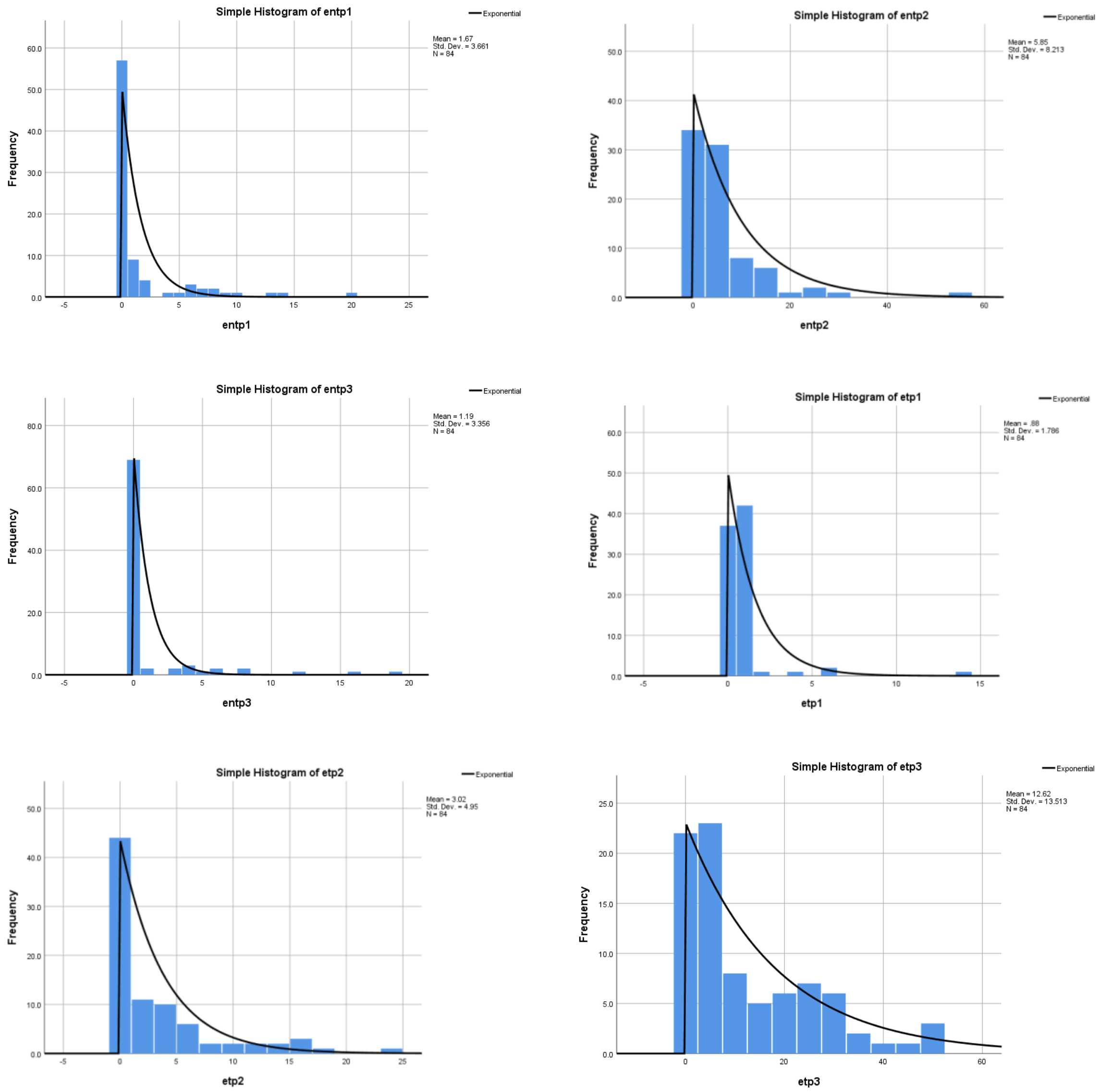

Figure 5. Factor Histograms

Analysis of Variance

A 2x3 repeated measures ANOVA has been performed to compare the main effects of NTP and TP conditions. The two extracted factors were summarized as Set (non-transverse patterning = 1, transverse patterning = 2) and Phase (1, 2, 3).

Bartlett's test of sphericity was significant ($\chi^2(20) = 425.49$, $p < .001$), but may be influenced by non-normal distributions. Mauchly's test of sphericity indicated that the assumption of sphericity has been violated for set * phase, $\chi^2(2) = 41.19$, $p < .001$, and marginally significant for phase, $\chi^2(2) = 5.63$, $p = .06$. Due to Huynh-Feldt $\varepsilon \gtrapprox .75$ for phase

($\varepsilon = .96$) and set * phase ($\varepsilon = .73$), Huyhn-Feldt corrections have been preferred over Greenhouse-Geisser.

Significant within-subjects effects have been found for set ($F(1, 83) = 22.05$, $p < 0.001$, $\eta^2 = .21$), phase ($F(1.92, 159.15) = 34.68$, $p < .001$, $\eta^2 = .30$), and set * phase ($F(1.45, 120.52) = 49.46$, $p < .001$, $\eta^2 = .37$).

Table 2

Factor Statistics

Source	Mean Square	*df*	*df* Error	*F*	*p*	Partial η^2	Observed Power
Set	856.45	1	83	22.05	.000	.21	.99
Phase	1396.02	1.92	159.15	34.68	.000	.30	1.00
Set * Phase	3436.10	1.45	120.52	49.46	.000	.37	1.00

Mean differences in attempts for set were $M = 16.90$, $SE = 0.35$, 95% CI [16.20, 17.60] for non-transverse and $M = 19.41$, $SE = 0.61$, 95% CI [18.30; 20.72] for transverse factors. Pairwise comparison was significant, $p < .001$. Mean differences in attempts across phases were $M = 15.27$, $SE = 0.25$, 95% CI [14.83, 15.72] for Phase 1, $M = 18.44$, $SE = 0.58$, 95% CI [17.28, 19.59] for Phase 2, and $M = 20.91$, $SE = 0.76$, 95% CI [19.39, 22.42] for Phase 3. Pairwise comparison was significant, $p < 0.05$.

Levene's test of equality of error variances was significant for ntp1 ($p = .005$) and tp1 ($p = .039$), but insignificant in all other phases. Mean differences in attempts were $M = 15.19$, $SE = 0.37$, 95% CI [14.46, 15.91] for ntp3 and $M = 26.62$, $SE = 1.47$, 95% CI [23.69, 29.55] for tp3.

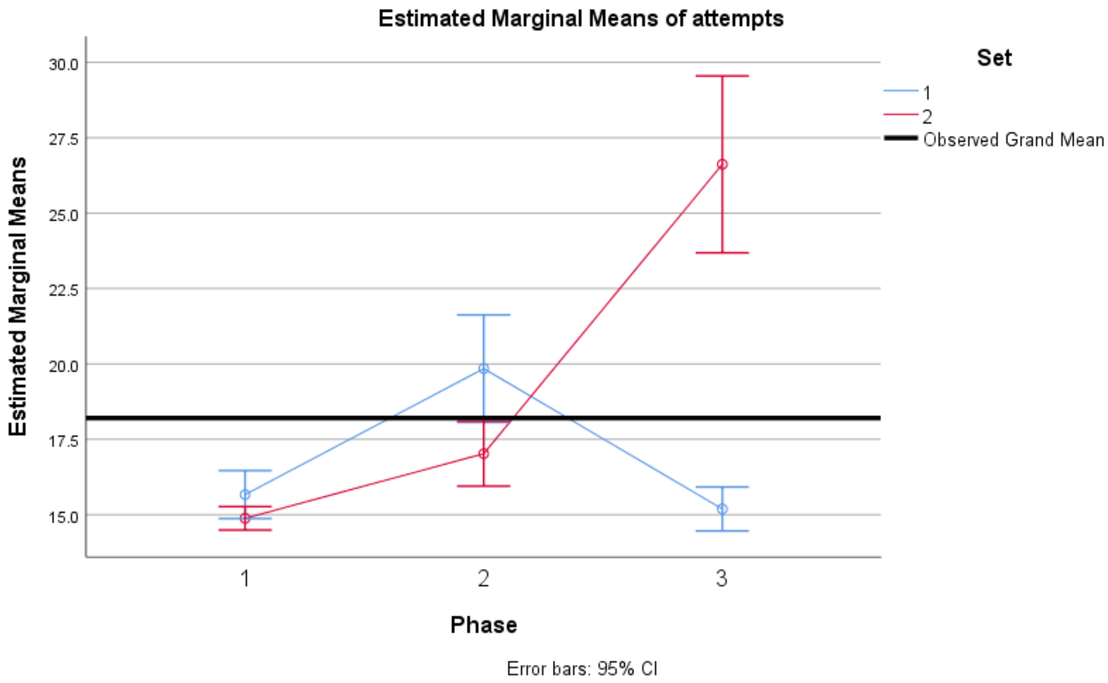

Figure 6. Estimated Marginal Means of Attempts

Pair-Wise Comparison

A paired samples t-test was conducted to compare Phase 2 and 3 in transverse and non-transverse conditions. Simple main effects have been found ntp3 and tp3 (M = 11.43, SD = 13.90, 95% CI [8.41, 14.45], $t(83) = 7.53$, $p < .001$), and ntp2 and tp2 (M = -2.82, SD = 8.37, 95% CI [-4.64, -1.01], $t(83) = -3.09$, $p = .003$). Whereas the participants needed significantly more attempts for Phase tp3 than npt3, less attempts were needed for the tp2 task compared to ntp2. The difference between ntp2 and tp2 suggests a continued learning effect across non-transverse and transverse conditions. Between-subject analysis indicates some correlation of tp3 with ntp2 (r = .37) and tp2 with ntp2 (r = .27). As expected, there is an absence of correlation of tp3 with npt3 (r = .006), and some correlation of tp3 with tp2 (r = .44). Thus, hypothesis H1 can be accepted.

Influence of Gender

A multivariate test of transversity * gender, step * gender, and transversity * step * gender did not indicate any significant results. A univariate analysis revealed a significant between-subject effect of age and gender, $F(1, 82) = 7.43$, $p = .008$. Female participants (M = 35.91, SE = 1.39, 95% CI [33.15, 38.66]) in the sample were significantly younger than the male participants (M = 42.13, SE = 1.81, 95% *CI* [38.52, 45.71]). Age and gender related effects are therefore difficult to distinguish within this sample. This observation is not relevant for the initial hypotheses. As an influence of gender could not be established, hypothesis H2 can be accepted.

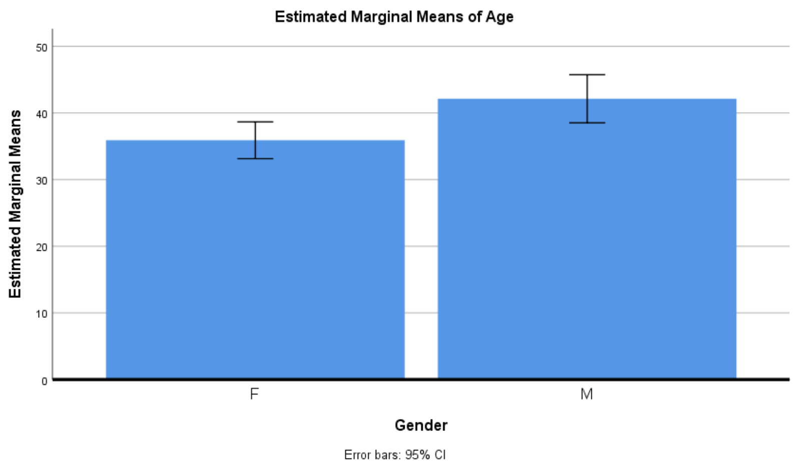

Figure 6. Estimated Marginal Means of Age on Gender

Influence of Age

Owing to the sparse age distribution of subjects, no age groups were created to avoid artefacts from grouping strategy. A linear correlation of age with all six groups did not show any significant results. To assess the within-subject effect of age on the difference between ntp3 and tp3, variable dtp3 has been derived as *tp3 – ntp3*. Pearson product-moment correlation coefficient indicated linear correlation between age and dtp3 ($r = -.20$, $p = .03$). A simple linear regression was calculated to predict dtp3 based on age. An only marginally insignificant regression equation was found, $F(1,82) = 3.53$, $p = .06$, with an R^2 of .04. Participants' predicted dtp3 is equal to 21.73 – 0.27 (age) attempts, when age is measured in years. Participants' attempts decreased by -0.27 for each year of age.

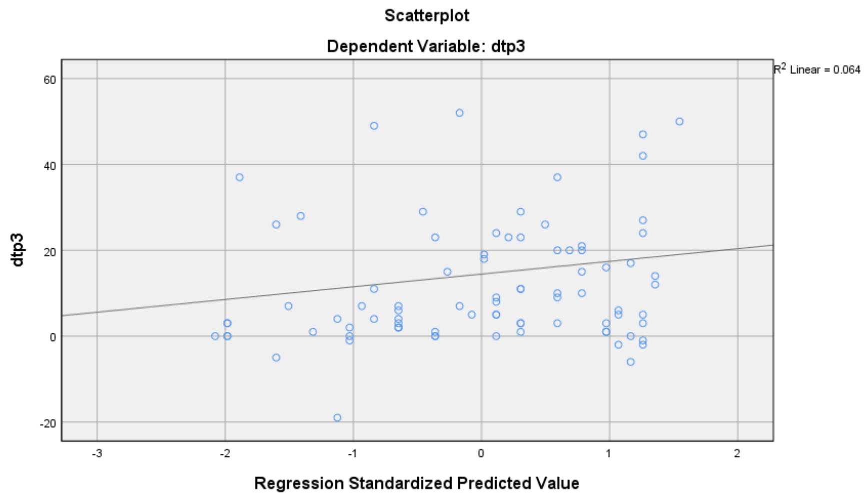

Figure 7. Scatterplot of tp3 difference on Age

Following the nonlinear distribution of tp3, a nonlinear regression has been attempted to improve the model. Variable "positive 1-based difference of tp3" (pos1dtp3) has been derived as *(tp3 – ntp3)* + 1 if $dtp3 \geq 0$, and 1 otherwise, normalising all participants who performed better or equal on tp3 than ntp3 to 1 for exponential regression. Whereas the linear model was no longer significant for pos1dtp3 ($F(1,82) = 3.27$, $p = .074$), an exponential model provided the best fit, $F(1,72) = 5.17$, $p = .025$. With low adjusted $R^2 = .048$, participant's $pos1dtp3 = 20.56e^{-0.029*age}$, when age is measured in years. Participants difference between tp3 and ntp3 will decrease times $e^{-0.029*age}$ for every year of age if $tp3 - ntp3 > 0$, i.e., if there is cognitive effort connected with tp3. Therefore, hypothesis H3 is accepted. No significant age-related decline has been found in this sample.

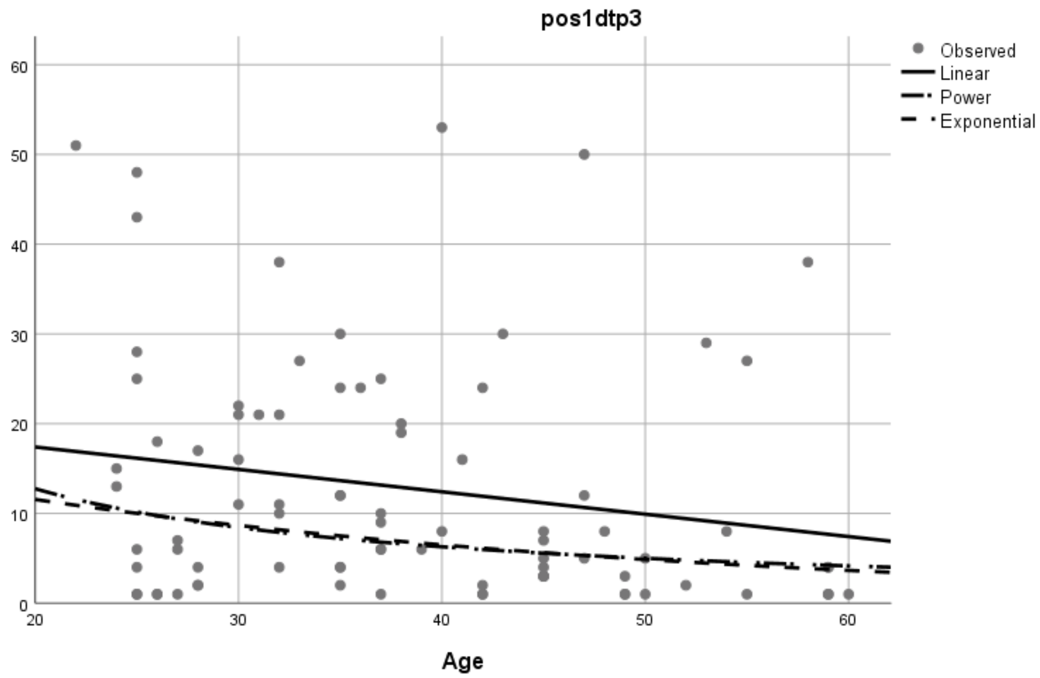

Figure 9. Linear & Exponential model for tp3 individual difference

Discussion

In a NTP vs TP learning experiment, 84 adult participants of both genders were assessed. As expected, participants at average needed significantly more attempts for the TP task compared to the NTP task. These findings confirm prior studies (Vervliet et al., 2011). However, single individuals managed all tasks at a comparable level, substantiating the influence of prior post-formal knowledge (Commons, 2009).

No age-related decline in TP processing has been found. Non-linear analysis even suggests a small improvement in performance with age. Likewise, no gender-related effect on TP performance has been found in the sample. Prior difference in male and female configural performance may thus not solely build on cognitive difficulty arising from spatial distance (Chamizo et al., 2011). However, Coluccia & Louse's (2004) cognitive difficulty hypothesis cannot be ruled out entirely, as there was a male gender bias towards the upper end of the age range in the sample.

Weaknesses & Conclusion

While there may be an old age or condition-related increase in TP processing, having only one participant above 60 years of age, conclusions about this group are out of scope of this investigation. Two more outliers greater than three standard derivations have been eliminated, as this experiment was conducted as an internet-based test that did not control for attention, completion times, click rates, or validity of statement of age and gender, or pre-existing conditions. The presence of cognitive conditions appears improbable in a sample of university Master students. On similar reasons, external validity for the general population can be doubted. Psychology students can be expected to have an above average general ability (Narikbaeva, 2016).

Subsequent research may explore the role of meta-systemic knowledge regarding age and transverse patterning performance in a larger sample. Particularly, experiments should be controlled for general ability, execution time, working memory performance, and spatial processing ability.

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