Mpdz (MUPP1)

1 Mouse generation

1.1 Mutation

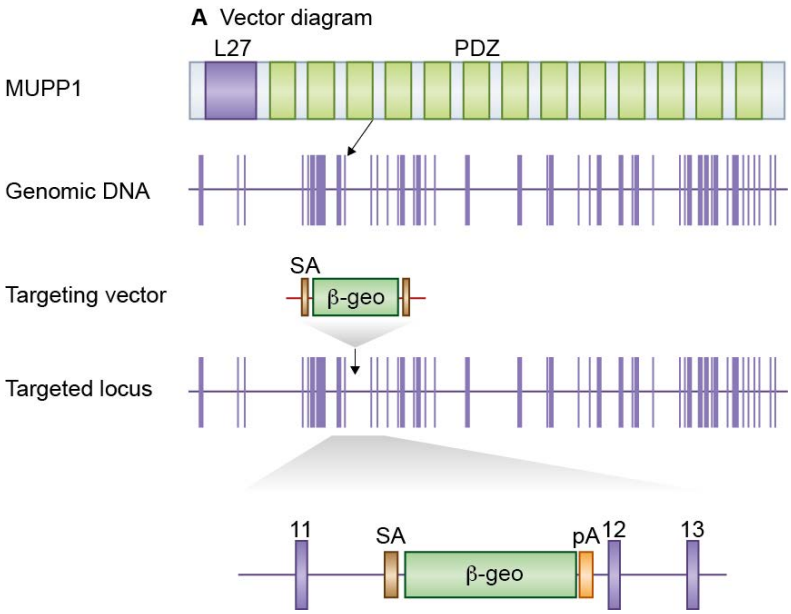

Figure 1: *Details of the mutation*

A mouse embryonic stem (ES) cell line (XG734, strain 129P2/OlaHsd) with an insertional mutation in *Mpdz* was obtained from BayGenomics (baygenomics.ucsf.edu/). The insertional mutation in XG734, by the gene-trapping vector, pGT1lxf, that was designed to create an in-frame fusion between the 5' exons of the trapped gene and a reporter, -geo (a fusion of beta-galactosidase and neomycin phosphotransferase II) occurred in intron 11-12. Thus, the gene-trapped locus is predicted to yield a fusion transcript containing exons 1 11 of *Mpdz* and -geo. The ES cells were injected into C57BL/6 blastocysts to create chimeric mice, which were bred with C57BL/6 mice to generate heterozygous *Mpdz* mutant mice. The severe hydrocephalic phenotype of IPNPZHPVT neonates resulted in generating them in the heterozygous state. Location of *Mpdz* gene trap. *Mpdz* is a 47 exon gene encoding the protein MUPP1 which contains an L27 domain and 13 PDZ domains (top). The *Mpdz* gene trap is located in intron 11-12.

1.2 Genotyping

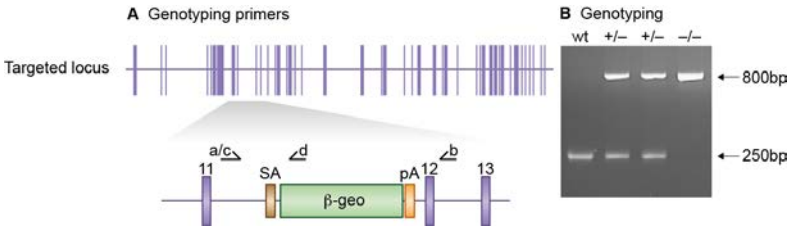

Figure 2: *Genotyping details*

Genomic DNA was isolated from ES cells or mouse tissues by Wizard SV 96 Genomic DNA purification system (Promega Cat A2371). Genotyping PCR consisted of 2 independent reactions. A 250bp product amplified from the wild-type (wt) allele using a forward primer A (5'- GTTCATACGGTTACTGTGGAG -3') upstream of the cassette and a reverse primer B (5'- CATAATGAAATCCTGAGCCTG -3') in the wt sequence deleted by targeted mutation. A 800bp product was amplified from the targeted allele using forward primer C (5'- GTGCGTCTGACACTGATGAGh) upstream of the insertion point with reverse primer D (5'- CTCTTCACATCCATGCTGAG -3'), within the -geo cassette. After enzymatic amplification for 35 cycles (45 seconds at 94 degC, 45 seconds at 55 degC, and 1 minute at 72 degC), the PCR products were size-fractionated on a 2% agarose gel in 1x Tris borate-EDTA buffer. Primers used for genotyping (a,b,c, d). PCR genotyping of gene trap *Mpdz* mice using primers a and b to amplify wild type alleles and primers c and d to amplify mutant alleles.

1.3 Breeding

Birth of .E $^{-/-}$ mice did not follow Mendelian ratios with 6% of offspring being homozygous knockouts; these progeny displayed increased perinatal mortality rates from birth to 4 weeks but tissue was collected for post mortem genotyping. Genotypes from .E $^{+/-}$ intercrosses identified 75 wt, 152 .E $^{+/-}$ and 14 .E $^{-/-}$ progeny (Chi-squared p= <0.001). Backcrosses onto the C57BL/6 background were used to maintain the .E colony and to generate heterozygous and wildtype mice to study. Genomic composition of the majority of mice used in experiments was approximately 25% 129P2/OlaHsd and 75% C57BL/6.

2 Behaviour

2.1 Definitions

Table 1: *Definitions of Behaviour Variables*

Experiment	Variable	Units	Description
Elevated Plus Maze	EPM total distance	cm	Total distance (cm) travelled in any arm or central zone of the EPM
Elevated Plus Maze	EPM max speed	cm/s	Maximum speed (cm/s) travelled in any arm or central zone of the EPM
Elevated Plus Maze	EPM % time in open	percent	Percentage of time in the open or closed arms of the EPM spent in open arms
Elevated Plus Maze	EPM time in centre	s	Total time (s) spent in the central zone of the EPM
Elevated Plus Maze	EPM max speed, open vs closed	cm/s	Difference between the maximum speed (cm/s) observed in the open arms and the closed arms of the EPM
Open Field/Novel Object	OF, NOE total distance	log10 cm	Total distance travelled (log10 cm) during initial exposure to the open field and in presence of the novel object
Open Field/Novel Object	NOE vs OF distance travelled	cm	Difference in distance travelled (cm) in presence of the novel object and during initial exposure to open field
Rotarod	RR naive fall time	log10 s	Fall time on accelerating rotarod (log10 s), naive performance in session 1
Rotarod	RR learning	s/trial	Learning on rotarod, measured as increase in fall time per trial (s/trial) in session 1
Rotarod	RR memory	s	Memory on rotarod, measured as excess fall time at middle of session 2 relative to middle of session 1
Fear Training	Fear learning, trial effect	percent freezing	Fear learning, measured as extra % time freezing before third trial compared to % time freezing before first trial
Fear Training	Fear learning, tone effect	percent freezing	Fear learning, measured as increase in % time freezing due to third tone compared to increase in % time freezing due to first tone
Contextual Memory	Contextual memory, mean	percent freezing	Contextual memory, measured as difference in % time freezing during first 120 s re-exposure to the box compared to first 120 s in the box on previous day
Contextual Memory	Contextual memory, change	percent freezing	Contextual memory, measured as increase in % time spent freezing from first time bin of 30 s to fourth bin of 30 s during 120 s re-exposure to the box
Cued Memory	Cued memory, mean	percent freezing	Cued memory, measured as increase in % time spent freezing during 120 s of tone re-exposure compared to increase in % time spent freezing during initial tone on previous day
Cued Memory	Cued memory, change	percent freezing	Cued memory, measured as increase in % time spent freezing from first time bin of 30 s to fourth bin of 30 s during 120 s re-exposure to the tone

2.2 Behaviour Overview

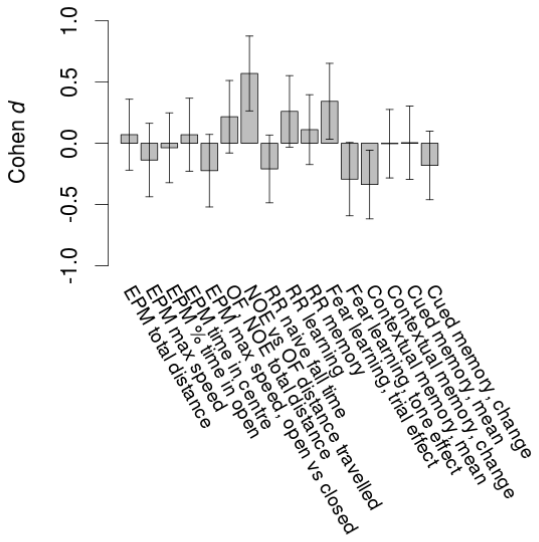

Figure 3: *Behaviour Overview. Alteration in a repertoire of eight innate and eight learned behaviour variables is shown. Cohen d effect sizes of the mutation are presented* $\pm$ *SE.*

Mutant mice showed no discernible overall behavioural difference from wildtypes. With heterozygous genotype and no behavioural variables significantly affected in mutants, this mutation was deemed haplosufficient.

2.3 Elevated Plus Maze - Innate/Instinctive Behaviour

Table 2: *Analysis of Innate or Instinctive Variables: mean(SEM) of behaviour scores for wildtype and mutant males and females, with p-values of differences*

Variable	Units	Wildtype M (n=13)	Wildtype F (n=10)	Mutant M (n=13)	Mutant F (n=14)	P(sex x mutation)	P(mutation)
EPM total distance	cm	974 (84)	1132 (120)	1067 (80)	1061 (81)	0.37	0.86
EPM max speed	cm/s	24.4 (2.8)	24.8 (2.2)	22.4 (1.5)	24.6 (2.3)	0.7	0.61
EPM percent time in open	%	7.8 (1.9)	8.7 (2.7)	6 (1.7)	9.6 (3.5)	0.6	0.84
EPM time in centre	s	58.2 (8.4)	77 (11.4)	67.7 (9.1)	69.5 (9.9)	0.39	0.88
EPM max speed, open vs closed	cm/s	-6.2 (2.5)	-6.8 (2.8)	-9.4 (1.4)	-7.2 (2.5)	0.55	0.43

EPM total distance: Total distance (cm) travelled in any arm or central zone of the EPM
EPM max speed: Maximum speed (cm/s) travelled in any arm or central zone of the EPM
EPM percent time in open: Percentage of time in the open or closed arms of the EPM spent in open arms
EPM time in centre: Total time (s) spent in the central zone of the EPM
EPM max speed, open vs closed: Difference between the maximum speed (cm/s) observed in the open arms and the closed arms of the EPM

2.4 Open Field & Novel Object Exploration - Innate/Instinctive Behaviour

Table 3: *Analysis of Innate or Instinctive Variables: mean(SEM) of behaviour scores for wildtype and mutant males and females, with p-values of differences*

Variable	Units	Wildtype M (n=13)	Wildtype F (n=10)	Mutant M (n=13)	Mutant F (n=14)	P(sex x mutation)	P(mutation)
OF, NOE total distance	log10 cm	3.46 (0.05)	3.52 (0.06)	3.51 (0.09)	3.55 (0.04)	0.84	0.5
NOE vs OF distance travelled	cm	-972 (154)	-805 (130)	-599 (119)	-703 (97)	0.29	0.06

OF, NOE total distance: Total distance travelled (log10 cm) during initial exposure to the open field and in presence of the novel object

NOE vs OF distance travelled: Difference in distance travelled (cm) in presence of the novel object and during initial exposure to open field

2.5 Motor Behaviour - Innate/Instinctive Ability, Learning & Memory

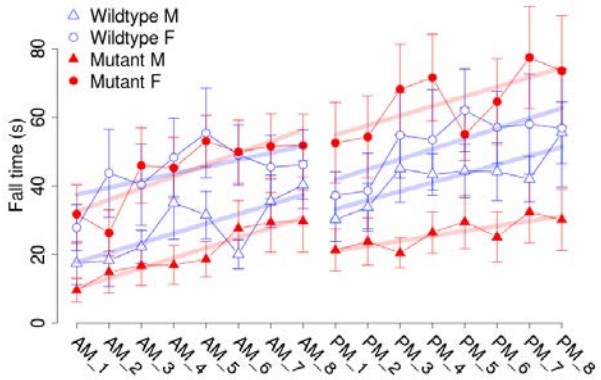

Figure 4: *RR histories. Mutant and wildtype (WT) males and females as indicated. Data represent mean ± SEM.*

Table 4: *RR analysis: mean(SEM) of behaviour scores for wildtype and mutant males and females, with p-values of differences*

Variable	Units	Wildtype M (n=13)	Wildtype F (n=10)	Mutant M (n=13)	Mutant F (n=14)	P(sex x mutation)	P(mutation)
RR naive fall time	log10 s	1.16 (0.1)	1.44 (0.15)	0.92 (0.12)	1.44 (0.09)	0.3	0.27
RR learning	s/trial	2.8 (0.8)	2 (1)	2.9 (0.8)	3.4 (0.7)	0.45	0.38
RR memory	s	14.7 (2.9)	7.7 (5)	5.7 (2.5)	20.2 (4.3)	0.0062 **	0.76

RR naive fall time: Fall time on accelerating rotarod (log10 s), naive performance in session 1

RR learning: Learning on rotarod, measured as increase in fall time per trial (s/trial) in session 1

RR memory: Memory on rotarod, measured as excess fall time at middle of session 2 relative to middle of session 1

2.6 Fear Conditioning - Learning & Memory

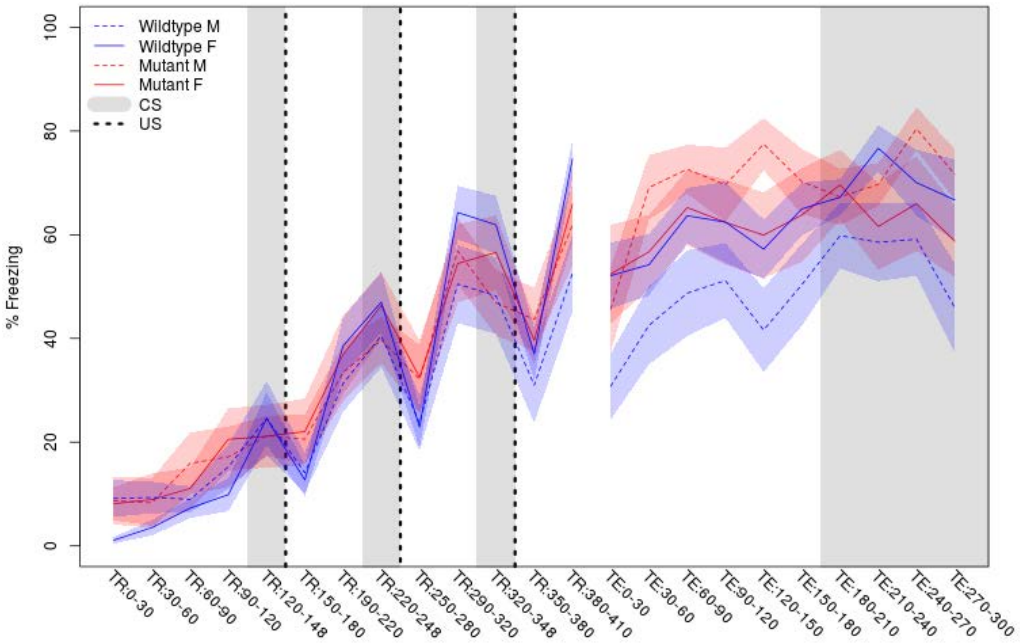

Figure 5: *FC histories. Percent freezing presented as mean ± SEM. TR:N-n, percent time spent freezing during time interval $N < t \leq n$ seconds on training day. TE:N-n, same on testing day.*

Table 5: *FC analysis: mean(SEM) of behaviour scores for wildtype and mutant males and females, with p-values of differences*

Variable	Units	Wildtype M (n=13)	Wildtype F (n=10)	Mutant M (n=13)	Mutant F (n=14)	P(sex x mutation)	P(mutation)
Fear learning, trial effect	% freezing	39.7 (6)	33.9 (9.3)	35.2 (6.7)	54.4 (4.7)	0.064	0.27
Fear learning, tone effect	% freezing	-14.1 (6.2)	1.5 (7)	-11.6 (6.9)	-17.1 (7.6)	0.14	0.29
Contextual memory, mean	% freezing	51.7 (4.6)	47 (5.3)	32.6 (6.4)	52.7 (5)	0.027 *	0.18
Contextual memory, change	% freezing	15.6 (9.3)	-2.4 (5.8)	14.3 (5.3)	1.5 (6.1)	0.71	0.87
Cued memory, mean	% freezing	-6.3 (5.5)	-3.2 (6.7)	-2.6 (6.7)	-6.9 (5.6)	0.55	0.98
Cued memory, change	% freezing	4.3 (5.2)	-10.9 (8.2)	-13.9 (7.7)	-0.5 (7.7)	0.057	0.53

Fear learning, trial effect: Fear learning, measured as extra percent time freezing before third trial compared to percent time freezing before first trial
Fear learning, tone effect: Fear learning, measured as increase in percent time freezing due to third tone compared to increase in percent time freezing due to first tone
Contextual memory, mean: Contextual memory, measured as difference in percent time freezing during first 120 s re-exposure to the box compared to first 120 s in the box on previous day
Contextual memory, change: Contextual memory, measured as increase in percent time spent freezing from first time bin of 30 s to fourth bin of 30 s during 120 s re-exposure to the box
Cued memory, mean: Cued memory, measured as increase in percent time spent freezing during 120 s of tone re-exposure compared to increase in percent time spent freezing during initial tone on previous day
Cued memory, change: Cued memory, measured as increase in percent time spent freezing from first time bin of 30 s to fourth bin of 30 s during 120 s re-exposure to the tone