Adding **manganese dioxide** powder to tinder would have made **fire-making** easier for **Neandertals**. However, **pyrite** dust also improves spark capture by **tinder**.

The utility of manganese dioxide as a Palaeolithic tinder enhancer supported by actualistic fire-making experiments

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Introduction

- The black mineral manganese dioxide (MnO_2) was collected and sometimes ground into powder by Neandertals in the late Middle Palaeolithic [1-4] (Fig. 1).
- Heyes *et al.* [5] showed that adding MnO_2 powder to woody material lowers its auto-ignition temperature by ~100°C, suggesting MnO_2 may have been useful for fire-making.
- This study tests the utility of MnO_2 powder as a tinder enhancer in actualistic fire-making experiments [6].

Methods

- The flint-and-pyrite fire-making method, known to have been employed by Neandertals [7], was used to produce sparks (Fig. 2).
- Three tinders of variable qulaity were tested: tinder fungus (*Fomes fomentarius*), black poplar (*Populus nigra*) and creeping thistle (*Circium arvense*) (Fig. 3).
- Six experiments were performed using each tinder (0.3 g): three mixed with MnO_2 (0.1 g) and three without (Control).
- Each experiment consisted of 100 spark-producing strokes (20 sets of 5 strokes), with the number of sparks captured per set recorded (Table 1).

Results

- The addition of MnO_2 to tinder greatly improved its ability to capture sparks, regardless of tinder type/quality (Fig. 3).
- Tinder fungus was the most effective tinder [6], followed by poplar and thistle, likely due to its fine, compact fibres.
- On average, MnO_2 improved the performance of these tinders over the controls by 140.5%, 133.4% and 114.6%, respectively.
- All tinders became more effective at capturing sparks as the experiments progressed (see trendlines), likely due to the deposition of a thin layer of pyrite dust.

Conclusion

- MnO_2 improves the spark capturing efficiency of treated over untreated tinder, thereby reducing the time and energy required to produce fire.
- However, the incorporation of pyrite dust into the untreated tinder over the course of the experiments appeared to improve its ability to capture sparks.
- Thus, pyrite powder added to tinder prior to making fire could also expedite the fire-making process, largely negating the need to collect MnO_2 for this purpose.

Figure 1. Manganese dioxide (MnO_2) blocks from Middle Palaeolithic layers at Pech de l'Azé I (Dordogne, France), two exhibiting grinding traces (a,c). After [4].

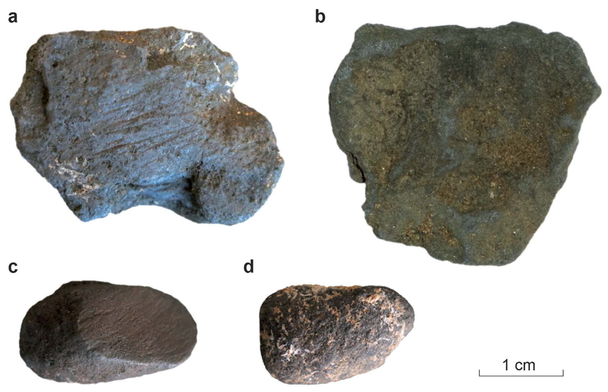
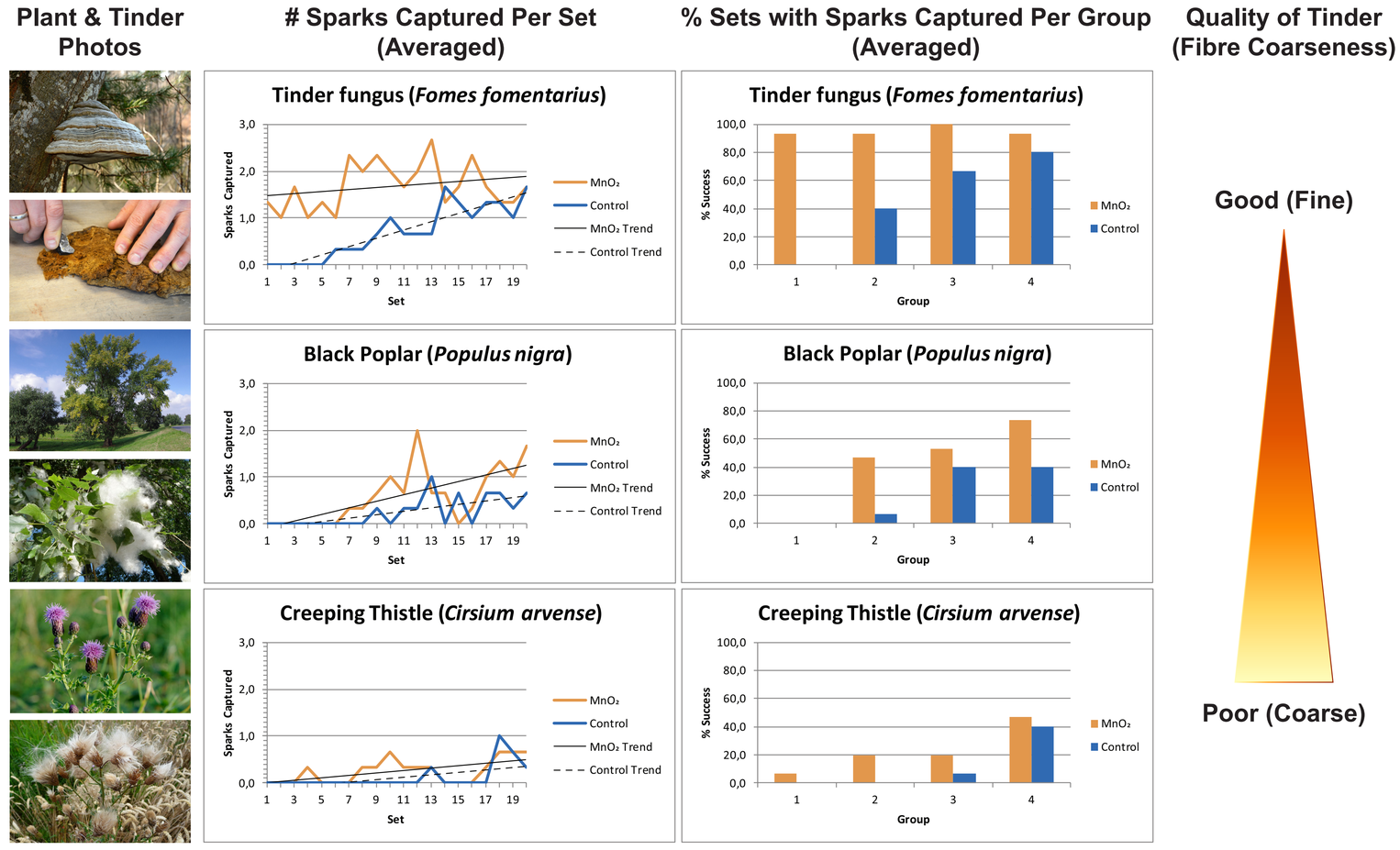


Figure 2. Gesture used for fire-making experiments. A flint crested blade was pulled forcefully upwards against a halved pyrite nodule producing sparks that fell into a small ceramic bowl of tinder (used for consistency).

Table 1. List of experiments using tinder fungus (*Fomes fomentarius*), as an example table showing experimental format. Listed are the total number of strokes, spark-producing strokes and sparks captured per set (Fig. 3, left), and in total. Colored bars delineate the percentage of sets per group of five sets where at least one spark was captured (Fig. 3, right).

Experiment	MnO_2/ Control	Set	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Totals
		Group		1					2					3					4					
1	C	Strokes	10	6	8	9	7	8	13	10	11	10	10	6	5	5	6	6	6	6	6	10	158
		Sparks	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	100
		Captures	0	0	0	0	0	0	1	1	0	0	1	2	2	1	1	1	2	2	2	3	19
		% Success		0					40					100					100				60
2	C	Strokes	7	5	6	8	5	5	6	10	6	6	7	7	8	6	6	6	7	6	6	8	131
		Sparks	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	100
		Captures	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2	0	0	1	0	1	6
		% Success		0					20					40					40				25
3	C	Strokes	6	7	6	8	8	9	6	6	6	6	6	8	6	8	7	6	7	7	9	6	138
		Sparks	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	100
		Captures	0	0	0	0	0	1	0	0	2	2	1	0	0	3	1	2	2	1	1	1	17
		% Success		0					60					60					100				55
4	M	Strokes	9	8	8	6	5	5	7	8	5	11	7	9	8	7	8	7	6	8	11	10	153
		Sparks	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	100
		Captures	3	1	2	1	1	1	1	2	2	2	2	3	3	2	2	3	3	2	2	2	40
		% Success		100					100					100					100				100
5	M	Strokes	12	11	5	7	6	8	6	5	7	5	5	6	8	9	5	7	8	5	8	6	139
		Sparks	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	100
		Captures	0	1	2	1	1	2	3	3	3	2	2	2	3	1	1	3	0	1	1	2	34
		% Success		80					100					100					80				90
6	M	Strokes	8	8	7	7	9	5	9	10	9	10	5	7	8	7	7	7	5	6	7	8	149
		Sparks	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	100
		Captures	1	1	1	1	2	0	3	1	2	2	1	1	2	1	2	1	2	1	1	1	27
		% Success		100					80					100					100				95
Averaged	C	Strokes	7,7	6,0	6,7	8,3	6,7	7,3	8,3	8,7	7,7	7,3	7,7	7,0	6,3	6,3	6,3	6,0	6,7	6,3	7,0	8,0	142,3
		Sparks	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	100,0
		Captures	0,0	0,0	0,0	0,0	0,0	0,3	0,3	0,3	0,7	1,0	0,7	0,7	0,7	1,7	1,3	1,0	1,3	1,3	1,0	1,7	14,0
		% Success		0,0					40,0					66,7					80,0				55
Averaged	M	Strokes	9,7	9,0	6,7	6,7	6,7	6,0	7,3	7,7	7,0	8,7	5,7	7,3	8,0	7,7	6,7	7,0	6,3	6,3	8,7	8,0	147,0
		Sparks	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	100,0
		Captures	1,3	1,0	1,7	1,0	1,3	1,0	2,3	2,0	2,3	2,0	1,7	2,0	2,7	1,3	1,7	2,3	1,7	1,3	1,3	1,7	33,7
		% Success		93,3					93,3					100,0					93,3				100

Figure 3. The line graphs plot the average number of sparks captured per set of five spark-producing strokes over the course of the fire-making experiments (left). The bar graphs indicate the average rate of spark capture expressed as the percentage of sets within a group of five sets of five spark-producing strokes where at least one spark was captured (right). Photos of the tested tinders (far left) and their relative quality/fibre coarseness (far right) are also shown.



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