

**1.** We “pull out” each of the operands of  $E = (u + v) + ((w + (x + y)) + z)$ . We perform this arbitrarily from left to right.

By the associative law,  $E$  can be transformed into  $u + (v + ((w + (x + y)) + z))$ . Thus we have  $E = u + E_1$  where  $E_1 = v + ((w + (x + y)) + z)$ . We trivially pull out  $v$  from  $E_1$  to get an expression of the form  $v + E_2$  where  $E_2 = (w + (x + y)) + z$ . With the associative law we transform  $E_2$  into an expression of the form  $w + E_3$  where  $E_3 = (x + y) + z$ . Similarly we transform  $E_3$  into an expression of the form  $x + E_4$  where  $E_4 = y + z$ . We transform  $E_4$  into an expression of the form  $y + E_5$  where  $E_5 = z$ . The sequence of transformations is

$$\begin{aligned} &(u + v) + ((w + (x + y)) + z) \\ &u + (v + ((w + (x + y)) + z)) \\ &u + (v + (w + ((x + y) + z))) \\ &u + (v + (w + (x + (y + z)))). \end{aligned}$$

**2.** We transform  $E = w + (x + (y + z))$  into  $F = ((w + x) + y) + z$ . We do so by “pulling out” one operand  $a$  from both expressions, which are equivalent, and then repeating with the next operand until none are left.

We first choose to “pull out”  $w$  from both expressions first. This is already so for  $E$ . By the associative law we transform  $F$  into